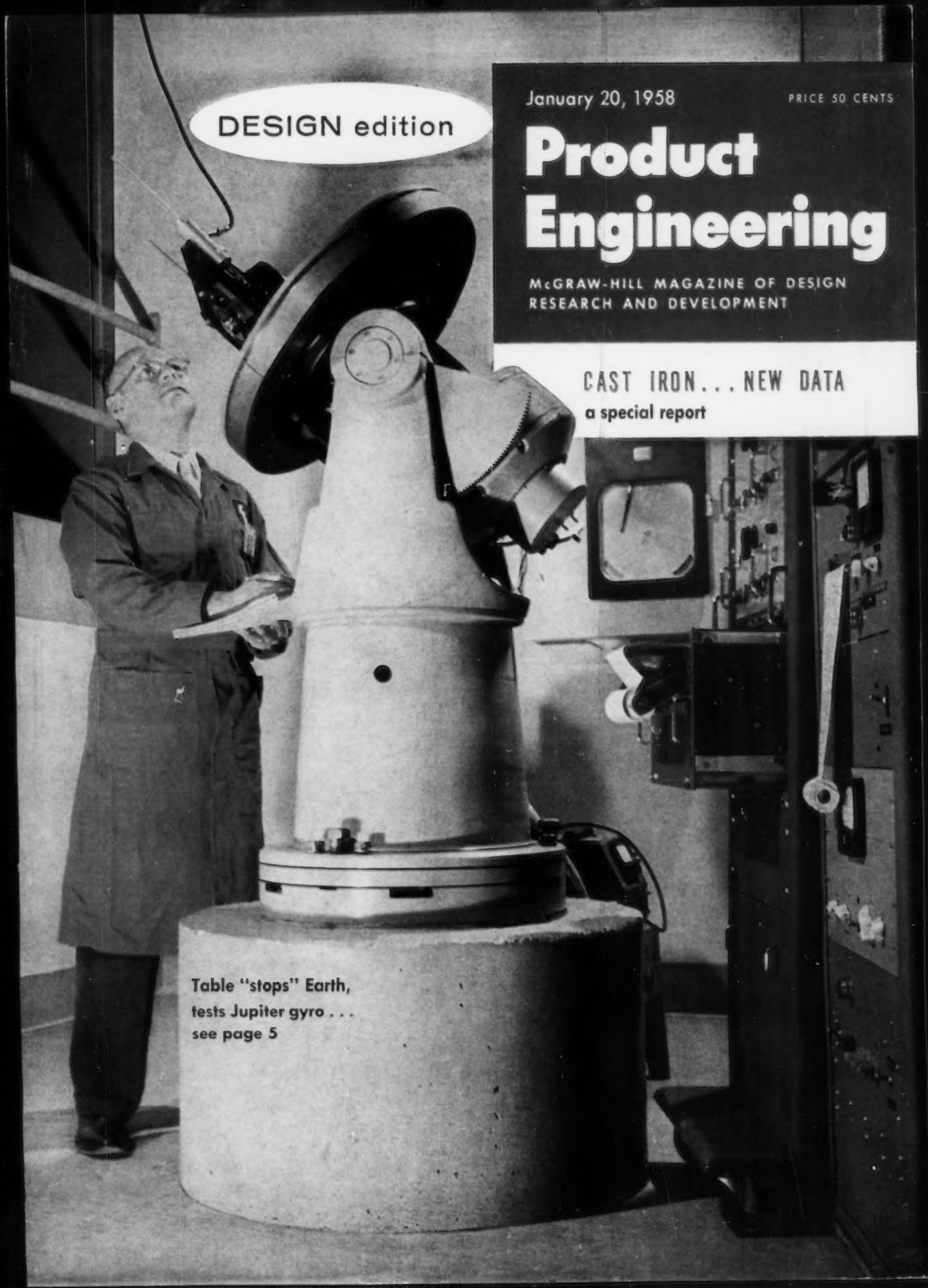


DESIGN edition

January 20, 1958 PRICE 50 CENTS

Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN RESEARCH AND DEVELOPMENT

CAST IRON... NEW DATA
a special report

Table "stops" Earth, tests Jupiter gyro . . .
see page 5

5,000 gallon fermenter with Cleveland horizontal unit mounted above it. At left is the fermentation room, with battery of 12 steel tanks, at Abbott Laboratories, North Chicago, Illinois.

For 10 trouble-free years, CLEVELANDS have served in mass production of Abbott's penicillin

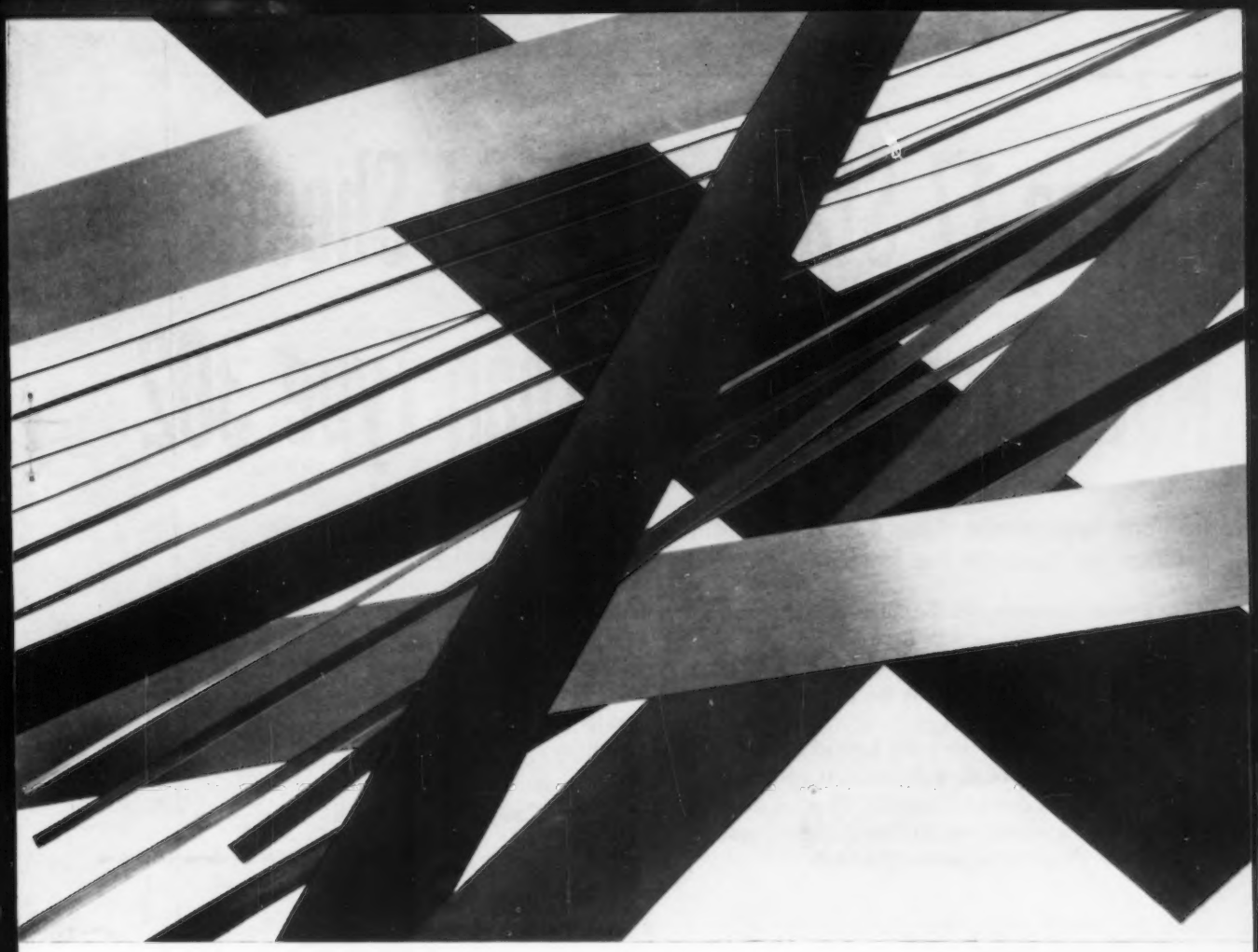
CONTINUOUS, uniform agitation of each batch is essential to proper processing of penicillin and other antibiotics. To insure uninterrupted, trouble-free operation at this leading pharmaceutical plant, Cleveland Worm Gear Speed Reducers were installed over ten years ago to drive the turbine impellers of a battery of 5,000 gallon fermenters.

In service continuously since 1946, these Cleveland drives have met every requirement. High yields have been the rule through the years. Only normal maintenance has been required. So far as life is concerned, the reducers are still "good as new".

Wherever trouble-free service and long life are a must in power transmission equipment, there your first choice is Cleveland. And there's a type and size for every need. Bulletin 145 shows the entire line of standard models, available when you need them. The Cleveland Worm and Gear Company, 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers, Limited.

CLEVELAND
Worm Gear
Speed Reducers



How these "educated" steels make products behave better

● Nobody will deny that there can be a vast difference between steels that are supposedly alike. The difference lies in "tremendous trifles" that often make all the difference between smooth and erratic fabrication or between satisfactory and faulty product behavior.

That's why the steels shown above are "educated", you might say—educated for special use. Because here at the *Athenia Steel Division* of National-Standard we've concentrated for years on learning about and *controlling* those tremendous trifles! In turn, this learning and experience is put right into the Athenia steels that successfully meet many of the toughest assignments known today.

If your production calls for cold rolled flat steels of .45 carbon or higher, from .015" to 16" wide and from .001" to .065" thick, it would be a good idea to explore Athenia quality, performance and service.

NATIONAL NS NATIONAL STANDARD **STANDARD**

DIVISIONS: NATIONAL-STANDARD, Niles, Mich.; *tire wire, stainless, music spring and plated wires* • WORCESTER WIRE WORKS, Worcester, Mass.; *high and low carbon specialty wires* • WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • ATHENIA STEEL, Clifton, N. J.; *flat, high carbon spring steels* • REYNOLDS WIRE, Dixon, Ill.; *industrial wire cloth*

Armco 17 Stainless Steel Sheets Now Cost 20% Less Than Type 302

In Many Applications, Type 430 delivers the most for the least

If you now use chromium-nickel stainless steels in products that don't come in contact with corrosive chemicals, sea water, or salt air, there's a chance that economical Armco 17 (Type 430) Stainless Steel can bring you substantial savings.

Today, for example, the price base of Armco 17 (17% chromium) Stainless Steel sheets is about 20 per cent less than that of Type 302. That's a saving of 11¼ cents a pound—$225 a ton! The reason is that Armco 17 contains no costly nickel.

Ideal for many products

If you have hesitated to specify chromium-nickel stainless steels for your products because of cost, it may pay you to investigate economical Armco 17.

Typical examples of products that can be improved with this low-cost stainless steel include architectural trim, appliance parts, tableware, counter tops, hospital equipment, sinks and drainboards. In addition, its resistance to heat scaling and strength at high temperatures have made it ideal for heat exchanger parts, combustion chambers, and similar items.

Mail the Coupon for Details

Armco 17 Stainless is readily available in both sheet and strip. Why not check to see if this economical stainless steel is suitable for *your* products? It is also supplied in bar, wire and billets—at lower cost too. Just fill in and mail the coupon for complete information. There's no obligation.

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Cold-Rolled PAINTGRIP®
Electrical Steels
Enameling Iron
High Strength Steel
Long Ternes
Stainless Steels
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Can we save money by making these parts from Armco 17 Stainless?

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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

JANUARY 20, 1958 **Vol. 29, No. 3**

SPECIAL REPORT

Gray Iron Castings— 52... Dr. F. R. Brotzen, J. F. Wallace, C. F. Walton
The high-temperature facts about this popular material have been incomplete and scattered. Now the Gray Iron Founders' Society has compiled the full story and permitted its presentation here ahead of publication in the forthcoming *Gray Iron Castings Handbook*.

Answer to Wiring Woe— 58... Dick W. Melville, Stanford Research Institute
Here's how a punched-card system helped keep track of 300 miles of wire and endless numbers of terminals in a computer.

Which Coating at High Temperature?— 61... G. D. Oxx, Jr., General Electric Co.
A guide to selecting protective coatings for corrosion resistance, erosion resistance, compatibility with underlying metal.

Design Features in New Products— 64... Equatorial table tests gyros; torque converter for tractor; cam varies spindle speed; grinder cycles automatically; skew rollers feed debarker.

Dynamic Gear Tester— 69... Jack Bieger, Daco Instrument Co.
Electronically controlled torque motor analyzes performance of a gear train.

Sandwich Panel Core Materials— 70... R. K. Humke, Minnesota Mining & Mfg.
Various design needs have led to the wide range of core materials now available. They are discussed in the light of possible applications and are laid out in a 2-page table for quick reference. First in a series of three articles on sandwich construction.

Multi-rate Helical Springs— 76... K. A. Flesher, North American Aviation
An unchanging deflection rate is sometimes a drawback. These two methods make use of springs in series to give a variable rate.

DESIGN FILE

Spring-loaded Holding Fixtures— 86... Sigmund Rappaport, Ford Instrument Co.
They are sometimes best choice for holding work. Here are ideas from Germany on six types.

Ratchet Layout Analyzed— 89... E. E. Rossner
Quick rundown gives generally unavailable formulas and data for optimum design.

Note new location for Developments to Watch, The Engineering Week, Reader to Editor in a special eight-page section starting on page 17.

Interesting to Note	5	New Components, Materials	93
Developments to Watch	17	Catalogs and Bulletins	122
The Engineering Week	19	Design Abstracts	131
Reader to Editor	24	New Books	134
Design Perspectives	47	Press Previews	145
Editorial	51		

STEMCO THERMOSTATS

for electronic and avionic applications

Features to fit your *special requirements* for avionic and electronic applications—from standard, production-line Stemco thermostats. That's just *part* of the Stemco story.

Because Stevens makes the widest range of bimetal thermostats in the industry, we offer an unusual number of basic design types . . . various terminal arrangements and mounting provisions . . . different temperature ranges and performance characteristics. In addition, Stemco thermostats feature small cubage, light weight and proven reliability—*at a production price.*

So get the Stemco story *first.* Write, call or wire *now* while your product is in the planning stage.

***Refer to Guide 400 EO for U. L. and C. S. A. approved ratings.**

TYPE A*

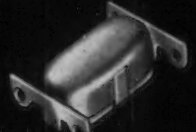
Semi-enclosed

Insulated, electrically independent bimetal disc gives fast response and quick, snap-action control. Operation from —10° to 400° F or higher on special order. Various mountings and terminals. Rated from 4 to 13 amps at 115 volts AC, depending on service conditions, 4 amps at 230 volts AC and 28 volts DC. Bulletin 3000.

TYPE A

Hermetically sealed

Electrically identical to semi-enclosed Type A. Temperatures from —10° to 300° F. Various enclosures and mountings, including brackets, available. For appliance, electronic, apparatus applications. Bulletin 3000.



TYPE C

Semi-enclosed

Small, positive-acting. Electrically independent bimetal strip for operation from —10° to 300° F. Rated at approximately 3 amps, depending on application. Terminals and mountings to customer specifications. Bulletin 3000.

TYPE C

Hermetically sealed

Electrically identical to semi-enclosed Type C but sealed in crystal can. Also supplied as double thermostat "alarm" type. Turret terminals or wire leads. Bulletin 5000.

TYPE M*

Semi-enclosed

Electrically independent bimetal disc type for appliance and electronic applications from —10° to 350° F. Rating: 8 amps at 115 volts AC, 4 amps at 230 volts AC and 28 volts DC. Virtually any type terminal. Bulletin 6000.

TYPE M

Hermetically sealed

Electrically same as semi-enclosed Type M. Can be furnished with pin or solder-type terminals, wire leads and various mounting brackets. Bulletin 6000.

STEVENS *manufacturing company, inc.*

Lexington and Mansfield, Ohio

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Interesting to Note . . .

Spinning with the World

It is significant that hanging at UN headquarters, New York, is a large pendulum demonstrating that every point on the earth's surface is rotating about every other because of the earth's rotation. This type of pendulum, first demonstrated in 1832 by a German, Herr Bohnenburger, led Leon Foucault to develop a practical gyroscope in 1852. The gyroscope is the heart of the guided missile that is such a sore spot in international understanding.

Actually, the gyroscope principle is as old as the first toy top or spinning wheel played with by a Chinese youngster. In 1836, a Scotsman, Edward Sang, read a paper before the Royal Scottish Society of Arts, suggesting an experiment with an instrument similar to the gyroscope by which the rotation of the earth could be shown.

Our cover picture shows an equatorial table at Ford Instrument Co. that simplifies testing of the Jupiter-missile gyro. The table is served by another gyro to stay fixed in space while the earth rotates under it. For how it's done see page 64.

The Lathe Master

One day at grammar school, young Thomas Blanchard heard about a machine that would pare apples. He was too shy to track down such an amazing gadget, so he imagined what one would look like—then built it. There were a lot of apple-paring bees in Massachusetts during the 1790's and Blanchard and his machine won blue ribbons at them all.

At 24, he built a tack-making machine that produced 200 tacks a minute. He later built an appliance that would mechanically finish the oval-shaped butt end of musket barrels. Soon he built a copying lathe which automatically carved a gun-stock. Next came shoe lasts, then firearms. His lathe designs were years ahead of the times. His varying spindle speeds even approached those with the type of lathe described on page 66.

Once he devised a copying lathe that would reproduce the busts of such notables as John Calhoun, Henry Clay and Daniel Webster. When his patent expired, he made a personal trip to Washington and made the unprecedented request before Congress for a second renewal. When some questions were raised, Blanchard took the three dignitaries to the basement and displayed his

(Continued on page 7)

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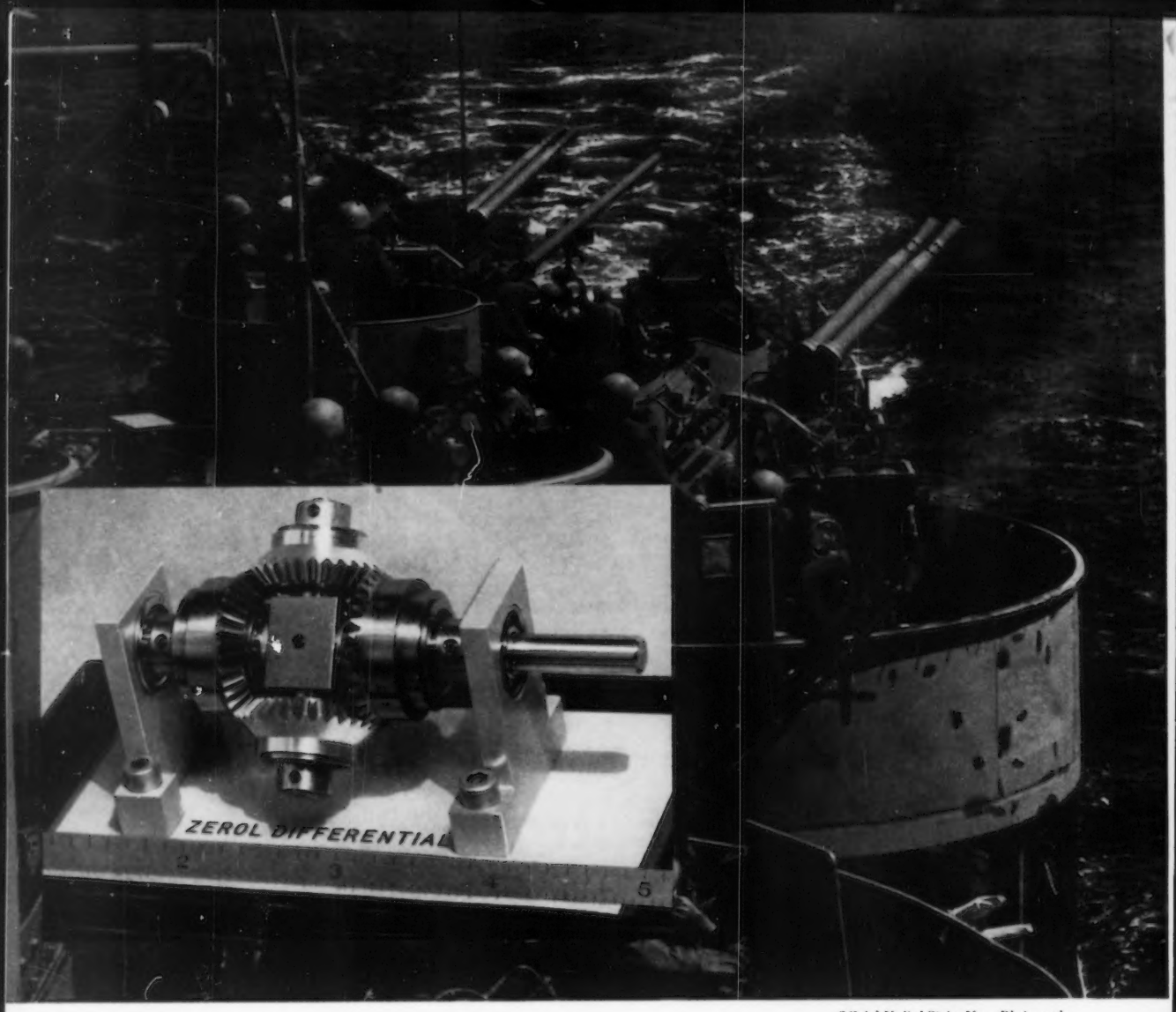

Official United States Navy Photograph

When your fine pitch gears *must be accurate*

When you work with fine pitch gears like those in this naval fire control unit differential, tolerances are critical.

Tooth-to-tooth accuracy is extremely important to permit the guns to be sighted precisely on target.

So where accuracy is really critical in the gears you make, Gleason can help you three ways:

1. Machines that cut or grind any fine pitch gear

You can produce any fine pitch gear—spiral bevel, hypoid, Zerol®, or Coniflex®—exactly and economically with any of five Gleason machines.

Three automatic gear-cutting generators cover the entire field of cut fine pitch bevel gears up to 4½" diameter. Two automatic, wet-type grinders are available for this same range of work and produce the ultimate in accuracy. All five work to your most rigid specifications.

2. Machines that test gears thoroughly

The Gleason No. 104 Hypoid Tester, for example, checks running qualities, tooth spacing, and concentricity of gears. It records test results on paper so that you have a permanent record of the total tooth-to-tooth composite error.

3. Engineering services

Gleason engineers are ready at all times to help you with any phase of the design and manufacture of fine pitch gears.

Simply write or phone for prompt assistance on any of your fine pitch gear requirements.

Send for these bulletins:

No. 2A Straight Bevel Coniflex® Generator
No. 103 Straight Bevel Coniflex® Generator
No. 2 Hypoid Generator
No. 105 Straight Bevel Coniflex® Grinder
No. 7 Hypoid Grinder
No. 104 Hypoid Tester

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Builders of bevel gear machinery for over 90 years

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copying lathe in action. With the help of Webster, he got his renewal and continued inventing lathes for America.

Immortal Linen

As soon as the meal was concluded and the final State toasts had been proposed, a medieval monarch would amuse himself and amaze his guests by pulling the cloth off the dining table and flinging it in the fire. After the guests' cries subsided, the King withdrew the tablecloth from the flames and spread it unscorched, before a bewildered audience. This monarch had come across the mineral, asbestos.

Actually this fire-resistant fiber was known by early Chinese and Egyptian civilizations. They wove it into mats and used it as a safe base under hot articles. The Romans found it and used it as a shroud, calling it *Linum Vivum* or immortal linen. If it couldn't be destroyed by the element fire, it would hold the soul for eternity.

More recently, asbestos has found many uses—in brake shoes and safety gear for fire-rescue work, to name but a few. (See the article on page 61 for discussion of high-temperature wire coatings.) Unfortunately, the supply of the raw material, chrysotile, is running short in this country. We produce less than 10% of the raw material we need. Russia, the world's largest producer, isn't anxious to trade. Present experiments, supervised by the Bureau of Mines, are uncovering some new materials. However, as yet, no synthetic fiber can fully duplicate the required properties of asbestos.

The Great Iron Rush

Driving on a country road to the annual Berkshire Music Festival at Tanglewood, Mass. last summer, we noticed a dilapidated pile of stones standing beside a water wheel. Upon investigation, we found them part of the ruins of a dead industrial center—the great Salisbury foundries.

It began in 1732, when Daniel Brissell moved to Salisbury (a small town in the northwest corner of Connecticut). While digging in his hilly land, he hit a rich vein of iron ore. The news spread, people flocked in to stake a claim. Samuel Forbes, Ethan Allen (before he led the Green Mountain Boys), Charles and George Caldwell, and Luther Holley (who created an iron dynasty that lasted four generations) were the big leaders in this ferrous-type gold rush. Soon, more than 50 blast furnaces were operating in the Salisbury area, dotting the sides of 2000-ft Mt. Riga.

Cannons and rifle barrels were forged from Salisbury iron. The embryo American Navy sent riders to order munitions and chains. Later, anchors and guns for the frigate Constitution were forged at Mt. Riga. The uses of iron were limited back in 1776 compared with what's being done with cast iron today, p. 52. However, the Salisbury folk boasted a $150,000 annual payroll; or, a payroll equivalent to that sum—these mountain people bartered with raw iron instead of money.

The vein started to run out in 1847; slowly the furnaces were abandoned. In 1923, the last iron worker left the mountain. Today a pile of stone by a waterwheel remains to tell a story of New England's great iron rush.

Then, Now and Tomorrow

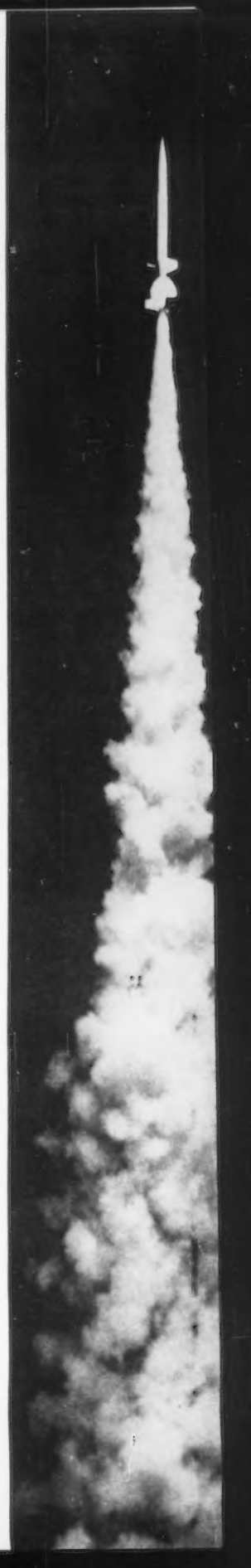
Just one hundred years ago, Cyrus W. Field, retired paper merchant, traveled across the Atlantic 64 times while proving his belief that an intercontinental network of direct communications would be profitable. Three times the Atlantic cable was stretched—then broken. When the cable finally did succeed, Field's first thought was to return to the spot of the last break, salvage it, and finish the job. This he did, giving the world two direct lines. Today there are 20.

Another interesting milestone a century ago was an attempt by the Texas government to import camels. The plan hit a snag, however. The Turks questioned our motive in building railroads over there while buying camels for over here. They thought we were trying to get rid of our railroads and adopt their *improvements*.

What about tomorrow? Well, scientists at a recent convention predicted: we'll control the size, shape and function of our bodies; no more mental or emotional sickness; plush excursion hotels on the moon; work week—4 to 8 hours; foods from the sun, sea and the laboratory. (See Perspectives, Dec. 23, p. 51.)

As for today, it's the missile that gets headlines. The Jupiter for example is discussed on page 64. Who would have thought when camels and cables were the talk of the day that rockets like this Navy Aerobee would be such a strong factor in our defense, cost of living, and even our economic structure a lifetime later? BENEDICT A. LEERBURGER JR.

Developments to Watch has moved to a new position starting on page 17, is increased to two pages, and combined with The Engineering Week and Reader to Editor in a special eight-page section.



IMPROVE DESIGN

Molded by Plax Corp.

BAKELITE BRAND POLYETHYLENE is used to make this squeeze bottle for the new Ipana Plus dentifrice. This dramatic departure from the conventional is typical of the possibilities of BAKELITE BRAND Plastics. Design advantages include full-range flexibility, simplicity of molding, improved functional performance and attractive finish that is pleasant to touch. Write for technical information.

BAKELITE PLASTICS BRAND ... do so much – so much better!

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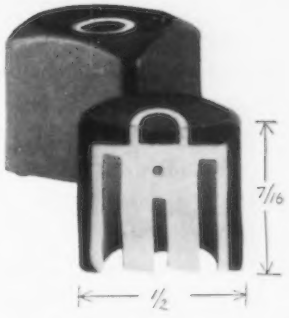
So—*don't make a design decision* until you have explored the proven advantages of BAKELITE BRAND Plastics and Resins . . . advantages that have improved style, color, finish, function and fabrication.

Bakelite Company will help you. Write for the latest technical literature. And remember, the skill and experience of BAKELITE Technical Representatives are at your service for special design problems. Their recommendations are backed by one of the largest research laboratories in the world. Write Dept. PEI-47



BAKELITE BRAND C-11 PLASTIC forms this "IBM" Electric Typewriter Key. Typical of the intricate design possible in small items with BAKELITE BRAND Plastics. Molded with "double-shot" technique . . . fine detail retained and overall cost cut. Colorful key has a beautiful, long-lasting finish that resists staining. Write for technical information.

Keys molded by American Plastics Corporation.

BAKELITE BRAND BMG-5000 PHENOLIC gives necessary impact strength and lasting beauty to top and base of this "Air Flight" Electric Fan Hassock. Formulated to take abuse, BMG-5000 has excellent molding characteristics—especially for thick sections and large moldings. It is also noted for its attractive appearance, high gloss, smooth surface finish, richness of color and superior electrical properties. Write for technical information.

Phenolic parts molded by Cambridge—Panelyte Molded Plastics Company, a subsidiary of St. Regis Paper Company.

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You effect major economies in time and money when you design and assemble small devices with self-locking microsize UNBRAKO socket screws. These close tolerance screws won't work loose. They simplify standardization of small devices where maximum reduction of weight is required without sacrifice of strength. They eliminate the necessity of designing costly special screws to fasten tiny parts in compact assemblies and they prevent the waste of production time while waiting for delivery of special screws.

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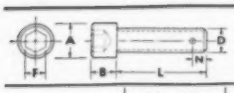
Ask your authorized industrial distributor for details today. He carries complete stocks of self-locking UNBRAKO socket screws (caps and sets from #0 through 1 in., button heads #4 through ⅝ in., flat heads from #4 through ¾ in.). Or write us for literature and samples. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 28, Pa.

*T.M. Reg. U.S. Pat. Off., The Nylok Corporation



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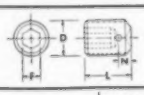
Self-Locking Microsize UNBRAKO Socket Cap Screws
Class 3A Threads

Screw Size		Threads per in. NC	Threads per in. NF	L Over-all Length	N Pellet Location NC	N Pellet Location NF	Torque Max. prev. on	Torque 1st off stat. min.	Torque 5th off stat. min.
#0	A .104	—	80	1/8	—	.047	5.5	14.0*	7.0*
	B .060	—	80	3/16	—	.047	5.5	14.0*	7.0*
	D .060	—	80	1/4	—	.047	5.5	14.0*	7.0*
	F .050	—	80	3/8	—	.047	5.5	14.0*	7.0*
#1	A .118	—	72	1/8	—	.047	11.0	28.0*	14.0*
	B .073	—	72	3/16	—	.047	11.0	28.0*	14.0*
	D .073	—	72	1/4	—	.047	11.0	28.0*	14.0*
	F .050	—	72	3/8	—	.047	11.0	28.0*	14.0*
#2	A .140	56	—	3/16	.063	—	24.0	3.0	1.5
	B .086	56	—	1/4	.063	—	24.0	3.0	1.5
	D .086	56	—	3/8	.063	—	24.0	3.0	1.5
	F 1/16	56	—	1/2	.063	—	24.0	3.0	1.5
#3	A .161	48	—	3/16	.063	—	40.0	6.5	3.0
	B .099	48	—	1/4	.063	—	40.0	6.5	3.0
	D .099	48	—	3/8	.063	—	40.0	6.5	3.0
	F 5/64	48	—	1/2	.063	—	40.0	6.5	3.0

*Measured in in.-gm. (those not marked with a star are measured in in.-oz.)



HEAT-TREATED ALLOY STEEL
Self-Locking Microsize UNBRAKO Socket Set Screws
Class 3A Threads

Screw Size		Threads per in. NC	Threads per in. NF	L Over-all Length	N Pellet Location NC	N Pellet Location NF	Torque Max. prev. on	Torque 1st off stat. min.	Torque 5th off stat. min.
#0	D .060	—	80	3/32	—	.047	5.5	14.0*	7.0*
	F .028	—	80	1/8	—	.047	5.5	14.0*	7.0*
		—	80	5/32	—	.047	5.5	14.0*	7.0*
		—	80	3/16	—	.047	5.5	14.0*	7.0*
		—	80	1/4	—	.047	5.5	14.0*	7.0*
#1	D .073	—	72	1/8	—	.062	11.0	28.0*	14.0*
	F .035	—	72	5/32	—	.062	11.0	28.0*	14.0*
		—	72	3/16	—	.062	11.0	28.0*	14.0*
		—	72	1/4	—	.062	11.0	28.0*	14.0*
#2	D .086	56	—	1/8	.062	—	24.0	3.0	1.5
	F .035	56	—	5/32	.062	—	24.0	3.0	1.5
		56	—	3/16	.062	—	24.0	3.0	1.5
		56	—	1/4	.062	—	24.0	3.0	1.5
#3	D .099	48	—	5/32	.093	—	40.0	6.5	3.0
	F .050	48	—	3/16	.093	—	40.0	6.5	3.0
		48	—	1/4	.093	—	40.0	6.5	3.0

*Measured in in.-gm. (those not marked with a star are measured in in.-oz.)

Self-locking microsize UNBRAKO socket cap and set screws are available in sizes #0 through #3, in heat treated alloy steel (plated or unplated) and stainless steel, at your authorized industrial distributor. He also carries a complete stock of other self-locking UNBRAKO socket screws.

We also manufacture precision titanium fasteners. Write for free booklet.

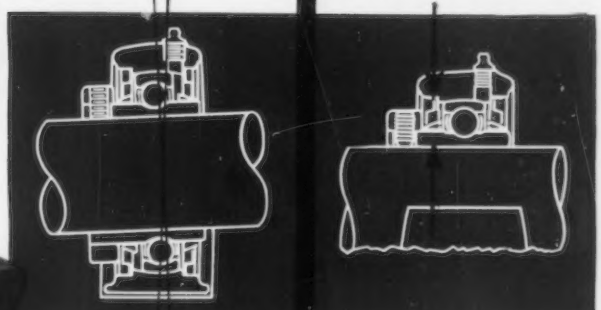
SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co., Inc. • Cooper Precision Products • Standco Canada Ltd. Unbrako Socket Screw Co., Ltd.

Self-aligning SEAL AND ALL

SELF-ALIGNMENT is assured because the lubricated, spherical outer ring is free to align in any direction. Full load capacity is always maintained regardless of shaft deflection or misalignment.

POSITIVE PROTECTION of the rolling elements from moisture, dust and dirt is provided by self-aligning seals extending from housing to inner ring. Large grease reservoir prolongs lubrication intervals.



Series 200 and 300 ball bearings

That's why grease stays in, dirt out of these LINK-BELT ball bearings

To compensate for supports and shafts that misalign in service . . . for unavoidable inaccuracies in mounting—Link-Belt offers self-alignment in ball bearings. And to protect that vital feature against dust and dirt, Link-Belt provides effective seals that *align along with rolling elements.*

Self-alignment is standard throughout industry's most complete line of ball and roller bearings—pillow blocks and flange, flange cartridge, cartridge and take-up units. Ask any one of 40 Link-Belt offices for Book 2550.

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self-aligning ball and roller bearings

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U. S. Army Redstone Missile

THE *FORWARD* LOOK

CHRYSLER CORPORATION

BRUNING Reproduction Machines help Chrysler Corporation in Vital Missile Work!

Most of the great work that Chrysler Corporation is doing in missiles must be classified for security reasons. It is no secret, however, that this progressive firm — creators of the advanced "forward look" in automobiles — has played a vital role in the development of the ballistic missile indicated above.

It is no secret, either, that Chrysler Corporation utilizes the outstanding advantages of modern Bruning Copyflex diazotype reproduction machines in this important work. Shown here is the imposing battery of Copyflex machines employed by the Chrysler Corporation. You can see for yourself the famous problem-free installation of Copyflex — no exhaust venting, plumbing, or auxiliary equipment. You can see, too, how Copyflex provides busy operators with such advantages as roomy feed tables, extra-large, convenient stacking trays.

And that's only part of the story. You, like Chrysler Corporation, should be benefiting by such modern Copyflex advantages as greater mechanical speeds, faster return of originals, synchronized exposure and development, automatic separation of originals from exposed prints, automatic stacking, and front-or-rear print delivery.

If you're not getting these important advantages, then every day you delay getting modern Copyflex is costing you time and money. Make the experience of Chrysler Corporation your basis for mailing the coupon below. You'll be glad you did!

Shown here is the impressive battery of Copyflex machines used by Chrysler Corporation for important reproduction operations in vital missile work. Machines need no venting, plumbing, or auxiliary equipment . . . provide Chrysler Corporation with important operating benefits.

Copyflex Gives You All These Advantages

Greater Convenience of Operation! Modern Copyflex gives printing widths up to 54" to simplify feeding of large tracings, facilitate multiple feedings. Such features as extra-large delivery trays, automatic separation, and front-or-rear delivery further speed operator's work.

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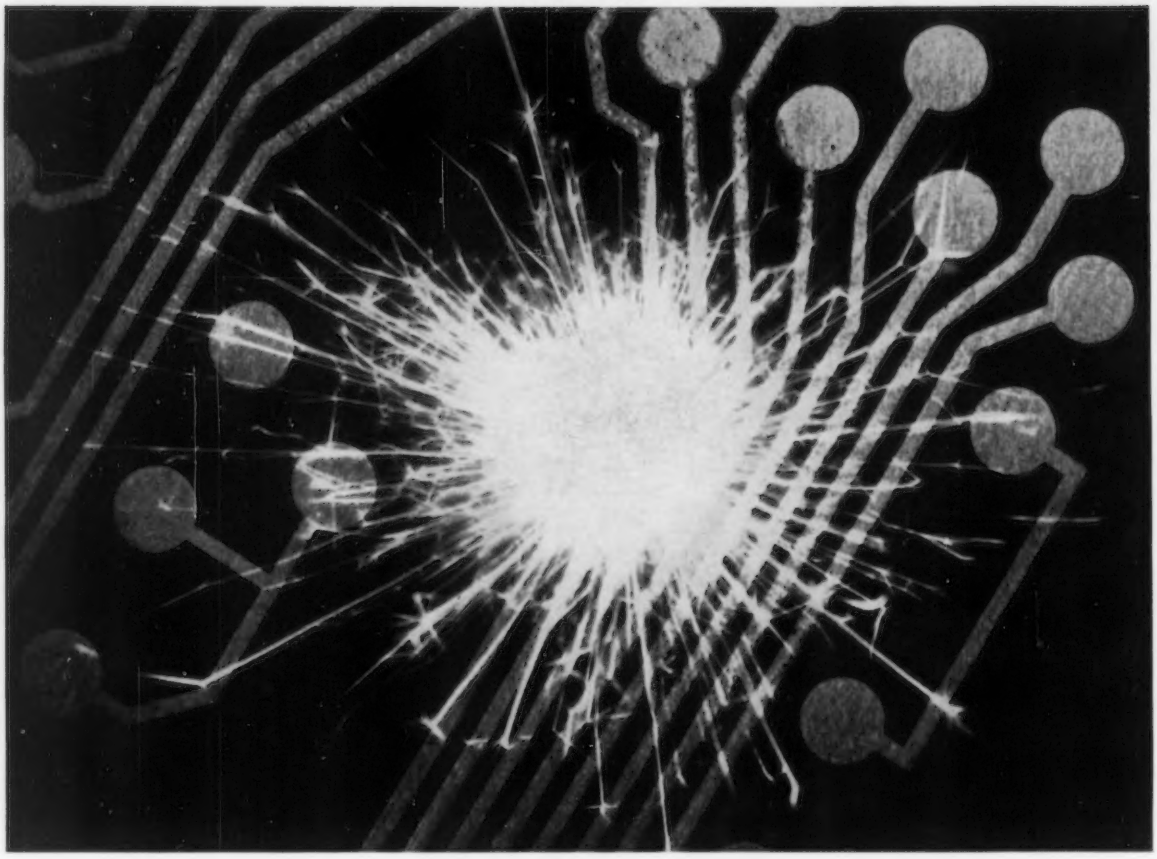
Please send me information on the Copyflex process and Copyflex machines.

Name_____ Title_____

Company_____

Address_____

City_____ County_____ State_____



Uniformity of Taylor Rolled Copper-Clad Laminates helps prevent shorts in printed electronic circuits

Taylor Rolled Copper-Clad Laminates help prevent both shorts and open circuits: shorts because the copper is free of lead inclusions; open circuits because the metal is free of pits and pinholes. They have such high uniformity that even lines only 0.002 in. wide, and spaced only 0.004 in. apart, can be produced. These features also help prevent resistance buildup and other faults that cause failures in radios, television sets, and other electronic devices found in the home and industry.

Production control at Taylor Fibre Co. is responsible for this highly uniform printed circuit material. Taylor has devised a unique method of bonding high-purity rolled copper to the base laminate—and keeping it securely bonded even under severe conditions of temperature, humidity and mechanical stresses. From this results the production of printed circuits of consistently high quality.

This is only one of the many Taylor Fibre Co. products that are meeting industry's demands for improved materials with superior performance characteristics. If your products require laminated plastics—in basic form or fabricated parts—contact the Taylor sales office nearest you. Save time and money by dealing with the right source of supply.

Actual size of printed circuit on Taylor Copper-Clad Laminate. The lines are only 0.002 in. wide and 0.004 in. apart.

TAYLOR
Laminated Plastics
Vulcanized Fibre

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INTEGRATED MANUFACTURER AND FABRICATOR OF PHENOLIC, MELAMINE, SILICONE, EPOXY, COPPER-CLAD, AND COMBINATION LAMINATES • VULCANIZED FIBRE

First and largest volume producer of rolled copper-clad laminates for printed circuits

A COMPLETE LINE OF SPACE-SAVING RELAYS

UP TO 4 CONTACTS
2 Normally Open
2 Normally Closed
Measures only
3-5/16″ high x 2-5/8″ wide!

UP TO 6 CONTACTS
4 Normally Open
2 Normally Closed
Measures only
3-11/16″ high x 2-13/16″ wide!

NEW!

UP TO 10 CONTACTS
Either 6 Normally Open and
4 Normally Closed or
8 Normally Open and
2 Normally Closed
Measures only
5″ high x 3″ wide!

- 600 VOLTS • 10 AMPERES • LONG LIFE
- ALL THREE SIZES HAVE IDENTICAL MOUNTING HOLE DIMENSIONS

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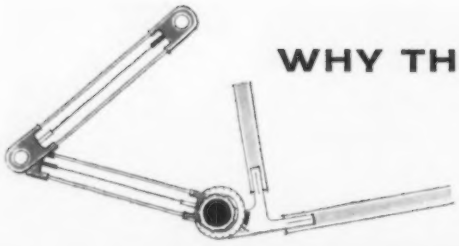
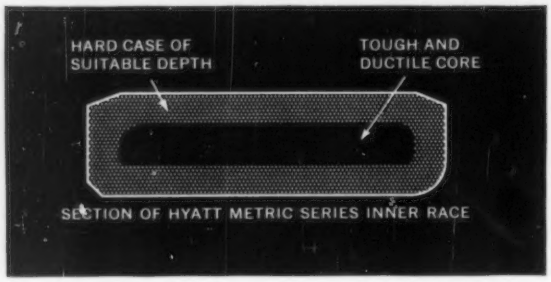
EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

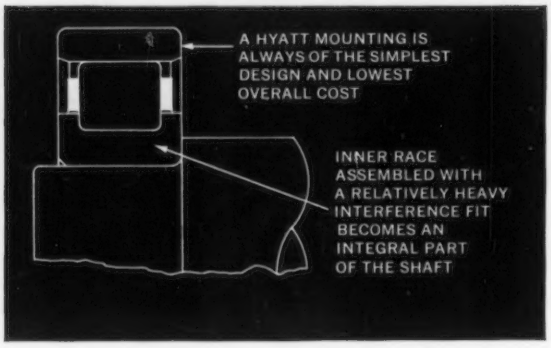


WHY THINGS RUN SMOOTHER WHEN YOU SPECIFY HYATTS

1. CARBURIZING PERMITS HEAVIER INTERFERENCE FITS



2. HEAVIER FITS SIMPLIFY MOUNTING, REDUCE COSTS


A HYATT MOUNTING IS ALWAYS OF THE SIMPLEST DESIGN AND LOWEST OVERALL COST
INNER RACE ASSEMBLED WITH A RELATIVELY HEAVY INTERFERENCE FIT BECOMES AN INTEGRAL PART OF THE SHAFT

HYATT PIONEERED THE USE OF CARBURIZING TYPE ALLOYS IN ORDER TO OBTAIN THE ADVANTAGES OF HEAVIER RACE FITS

To obtain the best possible performance, roller bearing races must be assembled on shafts and in housings with fits developed by design and experience. The most frequent condition to be met is a rotating shaft where specific load and speed conditions must be satisfied with appropriate race fits. These vary according to the manufacturer, and in the case of some manufacturers, according to the application. Naturally, the fits will also vary according to bearing type and size. How HYATT achieves the optimum in heavier race fits is detailed at right.

You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Pittsburgh; Detroit; Chicago; and Oakland, Cal.

1 With the standard metric series of cylindrical roller bearings there is a choice of two fitting practices: (1) Inner races of through-hardening steel, which dictates fairly light interference fits to avoid splitting. (2) Inner races of low carbon steel carburized and hardened to develop a suitable surface hardness and a tough ductile core. The latter permits much heavier interference fits and eliminates holding devices, because the race becomes practically an integral part of the shaft.

2 HYATT originated the carburized race and relatively heavy inner race fits to simplify bearing mounting and eliminate retaining devices. Practically all HYATT inner races are made from nickel alloys of the carburizing type. They permit the simplest kind of mountings and lowest overall cost, and their shoulders will withstand considerably greater impact loads than those of through-hardened races.

THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

1908–1958

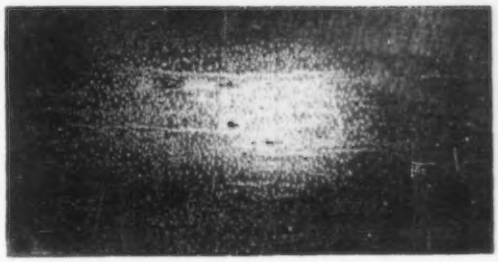
FROM THE PROGRESS OF THE PAST ... THE PROMISE OF THE FUTURE

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

DEVELOPMENTS TO WATCH...

Metal fatigue is proclaiming its presence . . .

. . . in an unusual way at the Bureau of Standards: by producing thousands of tiny bubbles (photo). Though small, they are nonetheless larger than the cracks they indicate, and visible to the naked eye. It had previously been shown (by time-lapse motion pictures) that material is extruded from metal-fatigue cracks as they form. Recently, an NBS researcher, anxious to obtain some of this material for study, covered a stressed specimen with transparent pressure-sensitive tape. To her surprise, bubbles soon began to form—visible long before fatigue cracks could be seen by the naked eye. A patent on the technique is being sought, and it looks as though it may well be applicable on a commercial basis. Best results have been obtained with aluminum alloys; Steel "bubbles" moderately. The method does not seem to work for brass or zinc.



Weight savings to 75% . . .

. . . in electrical and electronic equipment will be possible with new perfluorinated compounds, Minnesota Mining predicts. The company is now ready to produce a broad range of such compounds, in liquid and gaseous form, for use as transformer coolants, and in similar applications. Raytheon Manufacturing Corp., comparing these materials with chloro-fluorinated compounds previously used, finds the perfluorinates superior in stability at high temperatures and corona-inhibiting properties.

For transformer cooling, Raytheon has explored several design approaches: volatile fluorochemical liquids that vaporize when hot spots are encountered; partially filled enclosures in which the coolant is fed by wicking action; liquid and gas fill, using heat-conducting copper plates to transfer heat to an external radiator; and vacuum fill that limits the amount of expansion space required. As one example of weight and space savings, Raytheon cites a 500-cu in. transformer weighing 52 lb which was reduced to 280 cu in. and 27 lb by using a vacuum fill.

High-strength castings that can replace . . .

. . . forgings and weldments will be the goal of a million-dollar search by Chance-Vought Aircraft. C-V has been awarded an Air Force contract to develop foundry methods for casting complex shapes, like those pictured here, in high-strength steel alloys able to stand temperatures to 1000 F. C-V hopes to obtain castings with tensile strengths of 260,000 to 300,000 psi, save as much as 90% in fabrication costs.

Structural castings . . .

even more complex than these, and far stronger at high temperatures, are being sought in new C-V research project looking toward needs of the 2000-mph aircraft.

DEVELOPMENTS TO WATCH...

There are no "non-sparking" metals . . .

. . . say researchers at the Naval Gun Factory, following a study of "non-sparking" hand tools. Despite common belief, the researchers found that sparks—and subsequent ignitions—can result from using low-sparking materials such as copper. "Furthermore, sparks can be produced by contact between a non-sparking and a sparking metal or quartzitic rock. In general, the study also showed that impact, even at low velocity, is a more hazardous source of ignition than are friction sparks.

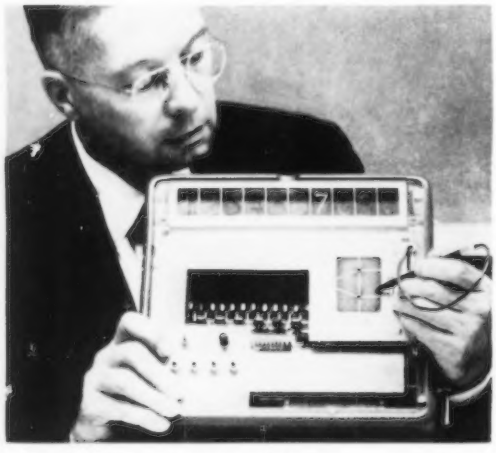
New family of spring alloys . . .

. . . developed in Japan is said to be suitable for use in power springs and tuning forks, as well as for watch springs. By varying the basic composition of these cobalt-nickel-iron alloys, Professors Hakaru Masumoto, Hideo Saito, and Takeo Kobayashi of the Research Institute of Electric and Magnetic Materials, Tokyo, say the temperature coefficient of the elastic modulus can range all the way from $+2.0 \times 10^{-4}$ to the minus values of conventional materials, while high values of elastic limit and yield point are retained. In addition to cobalt, nickel, and iron, the alloys contain small amounts of chromium, tungsten, and molybdenum, with fractional percentages of titanium, aluminum, vanadium, silicon, beryllium, magnesium, and polonium.

As one example, an alloy designed to replace 2% beryllium copper in power spring applications, is said to have a yield point and tensile strength after heat treatment 30 to 35% above that of beryllium copper. This particular composition contains 30% Co, 15% Ni, 0.5% Cr, 4% Mo, 0.7% Mn, 0.5% Si, 0.4% Al, bal. iron.

Handwritten numbers can be read automatically . . .

. . . and duly reported by a sensing machine that Bell Telephone Labs is developing. The numbers must be written in a special way (see diagram), and with a special pencil that leaves an electrically conductive line (or with a stylus that marks a plastic sheet in which are embedded electrically conductive vectors). But the system does work; in fact, it reads numbers as they are being written with greater ease than it reads previously prepared numbers. The reason: The sensing device can take advantage of the order in which the markings are made as well as the configuration of the number. —ARG



Experimental reading machine is here displayed by its inventor. Numbers can be read as they are written on the plate to which he is pointing; or previously written numbers can be read if they are written with conductive pencil, following guide dots as diagram indicates (a). In (b) is shown how sensing vectors pick up a written number, indicating the range of variation in writing which is permissible.

Pentagon to Copy British System of Weapons Development . . .

WASHINGTON—The Eisenhower adminstration is taking its first step toward centralized, civilian-controlled development of new military weapons. This will be a radical departure from traditional arms development handled by the individual armed services, and will ape Britain's method.

Sometime this month, Defense Secty. Neil H. McElroy is expected to issue a directive creating the "Advanced Projects Research Agency." This office, within the Defense Department but independent of the services, will control development of the infant ballistic missile defense system (the so-called "anti-missile missile"), reconnaissance satellites, space vehicles and platforms, and other new-fangled projects outside the traditional realms of the three military services.

Details of the new agency's operations are still unsettled. But one thing seems certain: APRA will have its own budget, will deal with development contractors, and—in its field—will direct the research efforts of the military services.

McCone Name Preferred

A leading candidate to head the new agency, according to Pentagon rumor, is John A. McCone, California shipbuilding and construction man. He knows his way around Washington, has been an Under Secretary of the Air Force, a deputy to the Secretary of Defense, and a member of the President's Air Policy Committee. The fact that a man of McCone's stature figures in the talk over who's to head APRA, evidences the intention to overhaul the administrative side of the weapon development program.

Under present plans, the new agency will turn over new weapon projects to the service assigned operational control of the missile, space ship, or whatever, after the equipment has been fully evaluated. Some defense experts, however, believe that by the time such things as anti-missile missiles and reconnaissance satellites become operational, the traditional organization of the military establishment will have been completely revamped too.

The APRA is the closest the US has come to the British weapon development system—a system which many of the critics of US defense policy want emulated here. In Britain, the military services originate requirements for new weapons. Then the independent Ministry of Supply determines the technical feasibility of such projects and follows through on development—setting up a budget, supervising design work, selecting contractors. Only after a new weapon has proved fully operational is it turned over to one of the armed services.

Brass Turning Angry

Pentagon services are reacting bitterly to McElroy's APRA plan. They charge that this so-called "single manager" of weapons development would "interfere" with the orderly process of designing new equipment, that there would be too little coordination between the designers and end-users of the new weapon.

A typical comment—from Maj. Gen. Bernard A. Schriever, who heads the Air Force's Ballistic Missile Development Program: "If you ever separate research and development of military weapons from the user, you are going to stretch the time of development."

Official announcement of the APRA organization has been held up for several weeks—a possible tip-off that service opposition to the plan may be forcing McElroy to water down the new agency's authority.

. . . But British Hope We Won't Do It

LONDON—At the same time that the US Dept. of Defense is making plans to duplicate the British method of weapons and plane development, some highly placed people in the British aircraft industry are urging the US to refrain from doing so.

One major complaint that some Britons have against their own system is the large number of non-technical civil servants with too much power. An official of one of Britain's leading aircraft companies told PRODUCT ENGINEERING, "Because the Ministry of Supply (MOS) has the money to spend, it is inclined to crack the whip over the services. Instead of inter-service rivalry, a three-cornered fight develops between the Ministry of Defense, the Armed Services, and the MOS," he added.

The MOS "too often sets itself up as an arbiter on what should and should not be done." Another spokesman for the industry said, "Many highly placed Ministry officials fail to grasp the significance and possibilities of a project because they have no real technical knowledge," he said.

These opinions were echoed by Sir Roy Fedden, one of Britain's leading aircraft consultants. He told PRODUCT ENGINEERING that the MOS "contains too many civil servants who make decisions at high level on subjects about which they cannot possibly possess authoritative information."

Fedden feels that the US method of having the services develop their own projects is "superior" to that of the British. "It is far better to have career engineers in the services developing projects than having non-technical civil servants directing affairs."

Asked how to eliminate inter-service rivalry in this system, Fedden said: "Discipline is the answer." He concluded by saying, "I would beg the Americans not to adopt the British method of weapons development and procurement."

How the MOS Operates

At Britain's Ministry of Supply, all aircraft, weapons and vehicles are procured for the armed services through "project officers." These officers are technical men who are directly responsible to the Minister of Supply.

Because of the complexity of mod-

ern weapons, the officers work in teams. In most cases the team consists of officers in charge of electronics and guidance, propulsion, and engineering on a project. The officers keep in constant touch with the companies or government research stations developing a project.

When one of the armed services conceives a new weapon or plane, specifications are submitted to the MOS. Discussions take place between the Minister of Defense, the Treasury, and the MOS. Development then starts either at one of the Ministry's research establishments, or bids are invited from a private company. Contracts are awarded by the MOS.

Present method of operation has been in existence since 1946, when the Ministry of Aircraft Production was amalgamated with the MOS.

In 1947-48, a US Department of Defense delegation visited Britain to examine the workings of the MOS. According to an official of the Society of British Aircraft Constructors, the delegation was "highly impressed". The MOS says it has received no further approaches from US.

Political Interference

Evidence of political motives interferring with development of new projects was shown this week by the announcement that the Bristol Aeroplane Co. and Hawker Siddeley are to join forces in building a civil jet aircraft for British European Airways. BEA is a state-owned airline.

Because the government desires amalgamations in the aircraft industry, the MOS has made it plain that the order for the airliner will only go to the company which falls into line with the government's wishes. BEA prefers a design developed by De Havilland. But as things stood at the beginning of the week, BEA apparently was being forced to settle for the second-choice Bristol 200 design. Bristol and the Hawker Siddeley group fell into line with the government's amalgamation policy by announcing a joint company to build the airliner.

Many observers here frankly attribute much of Britain's postway aircraft troubles to the Ministry of Supply. Britain is lagging a full generation behind US in development of fighter aircraft and as much as five years behind in Missiles by Prime Minister MacMillan's own admission.

Good after the last drop . . .
this klystron oscillator, retrieved following mid-air explosion in long-range missile and 1½-mile free-fall impact against the sea, is examined in electronic lab by Dr. Vincent E. Learned, Sperry director of klystron research (left), and Dr. Jack T. Muller, shock and vibration analyst. Dredged from the ocean floor, the precision component was found to work perfectly even though it had withstood shocks greater than 100 g.

Urge Maintenance Plans for War Hardware

LOS ANGELES—As equipment gets more complex, the problems of keeping it working grow worse in a snowballing progression. And the Armed Forces have been first-and-worst hit by those problems. Such was the complaint from military experts meeting recently with industry representatives at the Conference on Maintainability of Electronic Equipment.

The get-together was sponsored by the Electronic Industries Association and held at the University of Southern California. Among the big problems cited by military men was that caused by rapid turnover in military technicians. It makes maintenance of complex equipment an inherently high-cost, low efficiency operation.

Accordingly, Edward J. Engeron, Director of Maintenance Engineering for the Dept. of Defense, said the design engineer must plan for ease and economy of maintenance as well as for equipment performance. He cited the urgent need for defining maintainability in terms that can be incorporated into procurement specifications.

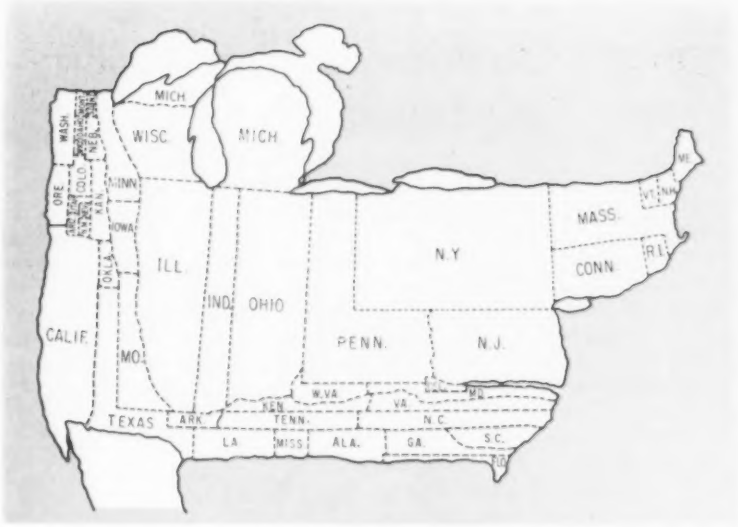
Such a definition was provided by Capt. F. K. Wheeler, Bureau of Ships: "A function of the ease and rapidity with which malfunctions can be detected and corrected under normal operating conditions." He said the Navy tries to bring its design, maintenance, and training personnel together with their industry counterparts early in the component design stages—so that Navy can "find the booby-traps before equipment hits the fleet." Others agreed that it isn't easy to decide the relative weight of maintainability in equipment design, but welcomed attempts by the services to set up some guides. There was also

agreement on the need to make initial provision for equipment maintenance wherever it can be done without a significant cost or performance penalty.

The two-day meeting also discussed application of existing instrumentation and computers for automatic check-out of complex systems, particularly in aircraft and missiles. One industry spokesman described a system, suggested to the Armed Forces, that would utilize a standardized tester connected to built-in devices in any missile or plane. This computer-analyzer would automatically run through a series of tests programmed for the unit under examination, and render an immediate "Go-No-Go" answer. If "No-Go," it would go ahead with a series of analytical tests to isolate the smallest replaceable malfunctioning unit, and would deliver a business-machine card identifying and locating the part needing replacement.

Feasibility of this concept is proved, it was pointed out, by the fact that most complex computers incorporate provision for self-analysis on a similar basis. Also, standard equipment is available with more-than-adequate versatility to duplicate all of the static and dynamic tests needed to check out any operational plane or missile. Such a system, Service officials conceded, would solve some of their biggest problems: prediction or detection, isolation and identification of malfunctions in the shortest time possible.

According to Capt. J. L. P. McCallum of the Bureau of Ordnance, the ideal missile would be one which was actually a maximum-reliability, zero-maintainability device composed of parts having identical service life. He asked electronic design engineers to make the most of what they know by selecting proven components where possible for operation well within design tolerances and load limits. For the present, he said, the Navy's Terrier and Talos missiles are repaired on shipboard only to the extent of "package level" replacements as indicated by "Go-No-Go" test equipment. Thus combat capability of a missile-equipped ship becomes a function of the number of spare "packages" that must be carried and the time required to trace malfunctions and make replacements.



Sealed chart shows states' relative industrial importance.

Shows States' Industrial Gains

CHICAGO—Many Western States have been expanding their manufacturing output over the past 10 years at a rate that far surpasses Eastern industry. But the bedrock concentration of industrial plants east of the Mississippi and north of the Mason-Dixon line was so enormous that relatively small gains there have meant large output gains. This revised view of the configuration of American markets results from a State-by-State survey conducted by the Russell T. Gray industrial advertising agency here. Chart above depicts state-by-state percentage growth from 1947-1954.

The survey was compounded of figures from the Industrial Census of 1954 and serves to prove, among other things, that manufacturers cannot place equal sales value on all States in the nation. It shows the relation of each State to the other 48, based on the value added by manufacture to the industrial products of the nation.

In the Middle Atlantic area, this value rose a relatively modest 46%; and in the East North Central States, 55%. But the rise adds up to a whopping $22.7 billion increase in the value of goods.

Pacific Coast States, on the tide of an expanding transportation equipment industry, boosted manufacturing output 104%—adding $5.7 billion to the value of their manufactured products.

Mountain States, where some of the most vigorous expansion has been occurring, piled up a 91% gain over the decade. But starting from an unindustrialized base this meant only a $710 million gain. In this area New Mexico, with a burgeoning chemical industry, carried off honors for rate of expansion. Value added rose from $32.8 to $127.1 million—a 297% increase. Arizona's new chemical, metal product and transportation equipment industries boosted its output to approximately $190 million—a 127% increase.

For 18 Southern States, output rose $8.2 billion. Heaviest gains show in the western portion where increases averaged 72%. Florida's food industry has been a major factor in its 124% increase to $785 million. Texas, with a triple-size chemical industry and double-size pulp and paper industry, shows a 104% increase for the period.

The New England States, starting with an industrialized economy, expanded a spare 31%. Manufacturing value added topped a decade earlier by $2.3 billion.

Secrecy Cloak on Gaither Report Shows R&D Lining

WASHINGTON–Crux of that much-discussed but not-yet-released Gaither Report promises more work for product planners. The secret analysis, prepared at Pres. Eisenhower's request by a group of VIBs (very important businessmen), is said to be loaded with recommendations for greatly expanding the program of researching and developing better military hardware.

As this edition went to press, the report was still under tight security wraps. But pressure from Congress was being put on the White House to release the tantalizing document. Congressmen were calling on the President to give the news about our military posture, good or bad, to the American public.

Here are some recommendations reportedly made by the Gaither group:

- Increase military spending to around $46-billion by 1960–that's about $8-billion more per year than we are now spending.
- Immediately, put more emphasis on fighting limited, non-nuclear wars. Long range, reorganize the military services to bring them in line with present-day missions and roles.
- Pool scientific knowledge with allies and spend more money for research and development of new weapons. Take steps to improve U. S. scientific educational programs.
- Start spending around $5 billion a year to build atomic bomb shelters.

Top names in the Gaither group included: Wm. C. Foster, ex-deputy Secretary of Defense, now with Olin-Mathieson Chemical Corp; John J. McCloy, of Chase-Manhattan Bank; Robert Lovett, financier and one-time deputy Secretary of Defense; Robert B. Sprague, of Sprague Electric Co.; and top man from such companies as Westinghouse Electric, Shell Oil, Bell Labs, M. I. T., University of California Radiation Laboratory, C. B. S., Airborne Instrument Laboratories, and Brookings Institution.

Initially, the Gaither report started out to be an evaluation of the nation's civil defense program. But it soon became evident that it would first be necessary to know Russian military capabilities and our own defense strength before an appraisal could be made of our CD needs. Result was a full-fledged evaluation of the defense structure of the country.

Already some action is being taken on many of the items recommended in the report. But there is no way of telling whether it was the initiating force.

UN Finds Europe Short on Science Teachers

ZURICH–A recent survey of the supply-and-demand balances of the European engineer population by the UN Economic Commission for Europe points up a current shortage of teachers in most nations because of low salaries paid in this field. Survey also shows that industry's personnel scarcity is most acute in the chemical and electrical engineering fields, owing to the rapidity of technical development in both these areas. Industry's shortage of engineers is greater than its scientist-shortage.

Also, the UNECE report reveals that Norway and France have the highest per capita number of engineers. There seems little correlation between a nation's degree of industrialization and its proportion of engineers. For example, Britain, the Netherlands, and Belgium, all highly industrialized, roughly have the same proportion of engineers as Italy and Greece, less industrialized.

Highest percentage of industry-employed, university-trained engineers is found in France (63%) and Britain (59%), with the smallest showing up in Portugal (28%), Holland (33%) and Denmark (35%). Highest percentage working in construction (41%) is in Switzerland, with Belgium tallying top percentage of engineers employed in commerce, banking, and insurance. Portugal uses 39% of its university-trained engineers in public administration.

Bits and Pieces

There are some economic optimists this year. Electrical manufacturers, through the National Electrical Mfrs Association, predict a $21 billion sales year in '58. This will be a gain of 1% over 1957, taking into account all sectors of the industry–appliances, illuminating equipment, industrial apparatus, insulating materials, etc. . . GM is tuning in on human heart beats. A new sound pick-up developed by GM and the Medical College of South Carolina will detect chest wall movements as small as one-half billionth of an in., inaudible to conventional recording instruments.

Calling All

Use of a magnetic drum storage device will make it possible for the British telephone system to route 100 calls simultaneously. The drum, a bronze cylinder measuring 3 in. in depth and 12 in. dia will "remember" numbers and translate them to routing instructions. It is now undergoing field trials at the Lee Green automatic exchange in London. Britain's first completely automatic exchange is scheduled for North London by 1960 . . . Pilots at Convair's Fort Worth installation are doubling as photographers to produce high-speed engineering studies on film. A pilot wearing a stripped-down gun camera (weighing 3.14 lb) on his head gear can photograph an object by pressing a button and looking at it.

New Elastic

B. F. Goodrich Chemical Company claims development of a nitrile rubber that resists ozone cracking. The company is using compounds of Hycar 1072 nitrile rubber soaked in ASTM No. 1 oil for 70 hrs at 212 F . . . The Univ. of California has tightened academic requirements. After 1960 graduates will be required to pass an exam in arithmetic, elementary algebra and plane geometry; take 12 units each in the humanities, social sciences and natural sciences, and 12 in a foreign language.

Many Reasons, One Fact—Germans Shun UK Plane

BONN—West German rejection of the Saunders Roe SR 177 has failed to produce a decision on an advanced interceptor for the German Air Force.

The Defense Ministry revealed its turndown in a letter to British Supply Minister Aubrey Jones. A German Defense Ministry spokesman explained that the SR 177 would not fit into the time pattern for GAF buildup. He denied that American political pressure had been exerted in favor of Lockheed or Grumman. The British have cancelled further work on the SR 177.

Still in the running for the intercept mission are the Lockheed F-104-A, Grumman's F11F-1, and France's Mirage 3-A, reportedly in that order. However, it is reliably understood that the procurement order will be for 100-odd planes instead of the 250-300 originally contemplated.

Military and industry representatives from the US, Britain and France had expected a firm decision before the end of 1957. British insistence that a yes or no to the SR 177 be given before Dec. 31 resulted in the formal rejection. Saunders Roe had promised to start delivery of its mixed-powerplant fighter in 1961. The German Defense Ministry says it wants to start phasing in the interceptors in 1960 but the British are understood to have received no advance notice that the 1961 date would be too late.

List of Reasons

Other reasons reportedly responsible for the rejection include: (1) A decisive shift in Defense Ministry thinking in favor of heavier reliance on missiles for air defense; (2) reluctance to go-for-broke on an unproven plane, especially with a national election coming up in 1961. Same thinking has pushed the Northrop N-156-F out of the top rank of contenders, although no rejection similar to the SR 177 has been announced to date; (3) a fresh spurt of interest in a vertical-takeoff craft becoming operational sooner than anticipated, possibly around 1963-64.

A Defense Ministry source revealed that a decision will not be taken on an interceptor during January. A minority view still holds that no commitment will be made before early spring.

Odds on various planes have fluctuated widely in recent weeks. Just before Christmas, the Grumman Super-Tiger had been tabbed as the choice. However, over the weekend, the Starfighter seemed to jump into the lead. A small team of Defense Ministry experts, including Chief Test Pilot Lt. Col. Albert Werner, returned on Christmas Eve from the US where he flew the F-104-A for the first time. He also flew the Super-Tiger again, giving rise to speculation on preferences for each.

Both the SR 177 and the N-156-F had been offered to the Germans as planes in which they could share in the development and adapt for the specific missions they require.

A decision is still pending also on the choice of a light-strike fighter, with Fiat's G.91 most mentioned.

COMING EVENTS

JANUARY

22-24 . . . . National Conference on Automation Systems sponsored by Electronic Industries Assn., Arizona State College, Tempe, Ariz.

27 . . . . American Society for Testing Materials—New Mexico, Arizona, Utah and Colorado District Conf. For information, contact J. L. Abbott, 1902 Richmond N. E., Albuquerque, N. M.

27-29 . . . . Annual Meeting, American Society of Heating and Air-Conditioning Engineers, Penn-Sheraton Hotel, Pittsburgh, Penna.

28-31 . . . . National Technical Conference, Society of Plastics Engineers, Hotel Sheraton-Cadillac, Detroit, Mich.

29-30 . . . . Midwest Welding Conf. sponsored by Armour Research, Illinois Institute of Technology, and Chicago Section, American Welding Society, at Illinois Tech Chemical Building, Chicago.

FEBRUARY

4-6 . . . . Society of the Plastics Industry, Reinforced Plastics Div., Edgewater Beach Hotel, Chicago.

MARCH

3-6 . . . . ASME Gas Turbine Power Div., Conference and Exhibit, Shoreham Hotel, Washington.

12-14 . . . . Pressed Metal Institute, Spring Technical Meeting, Sheraton-Cadillac Hotel, Detroit, Mich.

16-21 . . . . 4th Nuclear Engineering and Science Conf., managed by American Institute of Chemical Engineers, with participation by ASME, AIEE, American Institute of Mineral, Metallurgical, and Petroleum Engineers, International Amphitheatre, Chicago.

Experimental tractor . . .
combines general-purpose and row-crop units. Tandem hookup delivers up to 45% more drawbar pull than separate tractors pulling together. Swiveling front unit is controlled from rear through special linkage, with hydraulic cylinders providing steering control. Ford's Tractor and Implement Div. designed the four-wheel-drive unit, now being tested at several schools.

READER TO EDITOR

The Value of a License

To the Editor:

Your editorial, "Why Aren't Engineers Recognized?" (Dec. 9, p. 71) brings out several points on the registration of engineers that need to be discussed in more detail.

The main reason that more engineers do not register is that the examinations are not practical. They do not prove anything, except that a person has retained some of the mathematical theory that he studied during his college years. Nor does the fact that a person holds an engineer's license mean that he is an engineer. The difference between an engineer and a theorist is that the engineer must think in terms of the original idea. I have known several registered men who were experts at mathematics and theoretical mechanics but who could not originate terms for the simple bearing bracket. Their minds were so taken up with hypothetical cases that they could not approach the problem with the basic requisite of an engineer, which is common sense. Yet these men were licensed by the state as professional engineers.

An engineer's sole commodity is his ability to think. Theoretical solutions can only verify what the engineer originally suspected. Coupled with this is the intuition of designing. This is not the wild "I have a hunch" type of intuition, but that which makes a man feel he is heading in the right direction. This is the mark of the professional in any business and is referred to as business acumen. But a license examination does not provide for this.

How many times have you heard an engineer say, "I studied this once, but I don't remember it now?" And how many times have you said it to yourself? It is human nature that unless a process is used continuously, it soon is forgotten completely. At graduation the examination is not too difficult, due to the fact that the person's daily exercises keep him in trim for this type of questioning. However, when he enters industry it is likely that he will do drafting for a few years and as he advances into more active design, he will acquire an entirely new type of education. His problems will then be centered around a company's product. Textbook theories will fade from his memory. He does not need them, so why should he retain them? This is where our state examinations prove of no value; an engineer is expected to remember a lot of useless facts that he will never use. It would be a rare occasion, indeed, for the structural engineer to need to know the fly-ash content of a ton of coal. Likewise why should it be necessary for a chemical engineer to know the design and theory of turbines? To pass the examinations, however, he may be called upon to solve such theoretical problems. The only way he can assure himself that he has an even chance is to go to the trouble and expense of taking special or refresher courses. After he has passed the examination he is not likely to remember the refresher course for long.

Employers do not recognize a license as having much value because most of them know what the examination contains. A person can be on a drafting board, pass his examination, and then go right back to doing the same work he was doing before he went to all the trouble. The license hasn't advanced his proficiency. His employer probably knows more of his capabilities than the state board does. When he has demonstrated his ability, the company is willing to rely upon his judgment and give him the title of "Engineer." Who, then, can say that he is not an engineer? He does the work of an engineer; his employer, his friends and his family recognize his abilities and in most cases, this is sufficient for the man. There is, however, a prejudice among those who have registered and feel that everyone else should have to go through the same examinations that they did.

What value should a license have? What reason can be given for having it? It should be a definite assurance to an employer that a man is capable of doing original design, that he will not be lost in the complex maze of administration, that his moral and professional ethics are beyond reproach. Advancement preferences should then be given to those holding the license.

The foregoing may lead to the conclusion that I am against registration. I would like to make it clear that I am not. The registration act is commendable in its purpose. However, I do feel that the method of examining could provide a better index for professionalism. I believe that a much more practical examination would be:

1. Require a minimum of 10 years' experience before taking the examination.

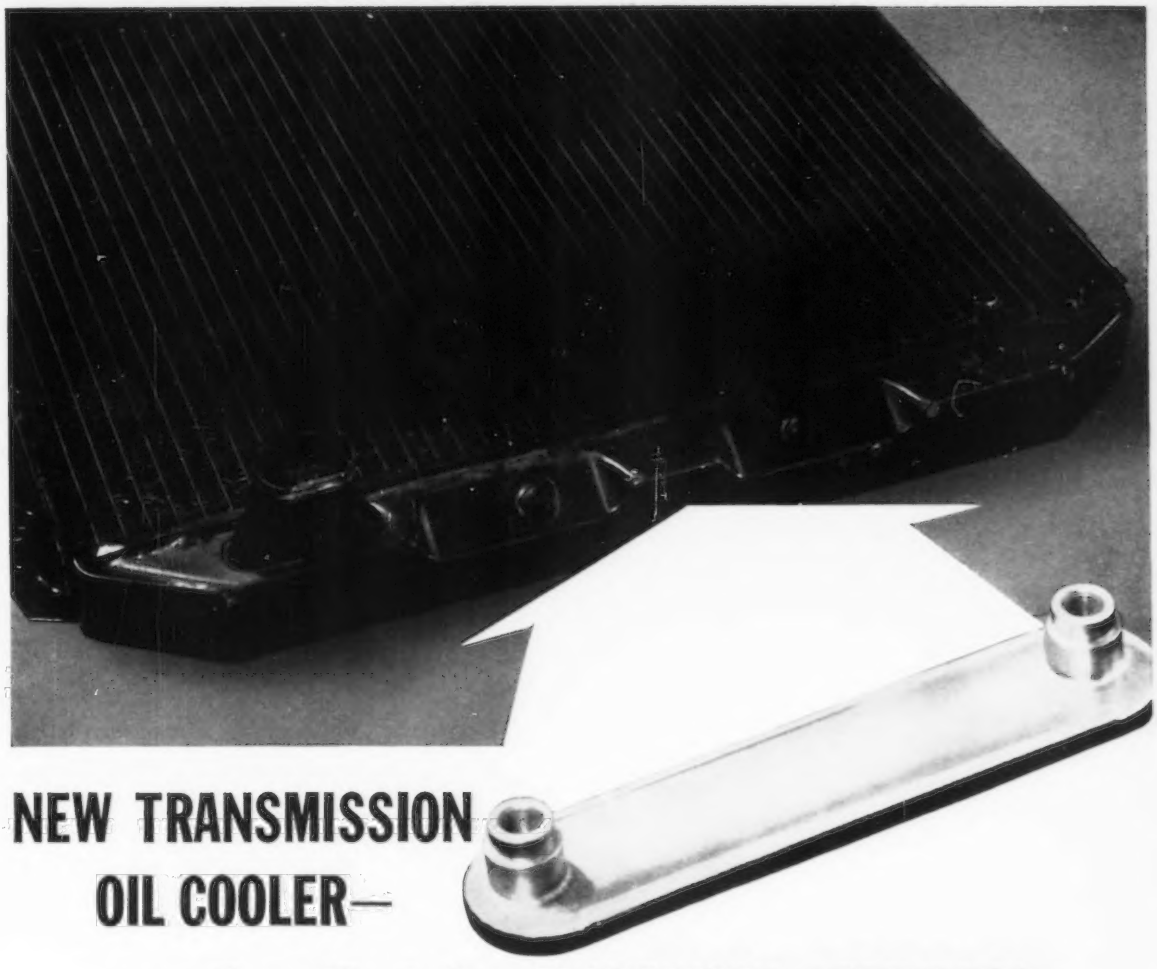
2. Recommendation by a minimum of five registered engineers who can give first-hand accounts of the man's experience and personal character.

3. Required solution of a complete, original design problem to be selected by the state board of examiners. This would include all calculations, all specifications, all plans complete in detail, and a written report giving reasons why each part of the design was carried out in such a manner. The project would be required to conform to all codes and standards. The time limit for such a project would be set by the examining board and the engineer could use any method he cared to in carrying it through, i.e. prepare all drawings, select his own textbooks or personal notes, etc. This would be done just as in actual practice. The project would be given in the man's specialized field and his license would be made to read accordingly, such as, "Mechanical Engineer—Machine Design."

I hope the day will soon come when engineers are recognized as the high-level professional people that they are. But, until such time as the registration examinations are designed to prove a man's capacity for his calling and raise his prestige in the eyes of the public and his employer, registration and professionalism will continue to have little attraction for the individual.

—BENJAMIN F. HARRISON, JR.
Oak Park, Mich.

• Mr. Harrison provides a practical answer to the problem that plagues so many critics of professional licensing—an examination that stresses the individual's field rather than civil engineering, and practical experience rather than book learning. We wish him luck.—Ed.



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Write for this 16-page Technical Study that describes alternate selections available for the Chrome-Nickel Stainless Steels. Gives properties, fabrication data, etc.

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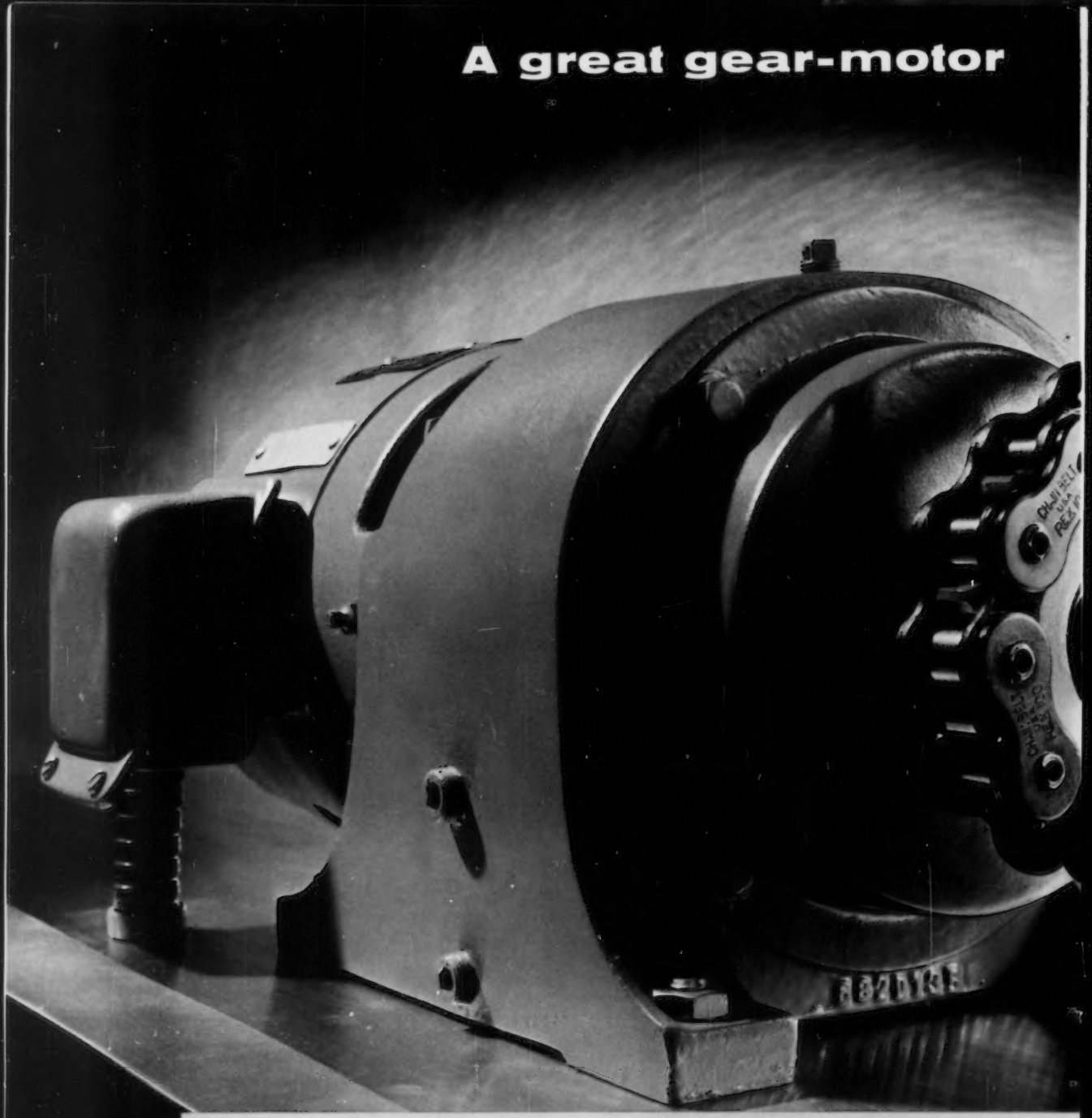

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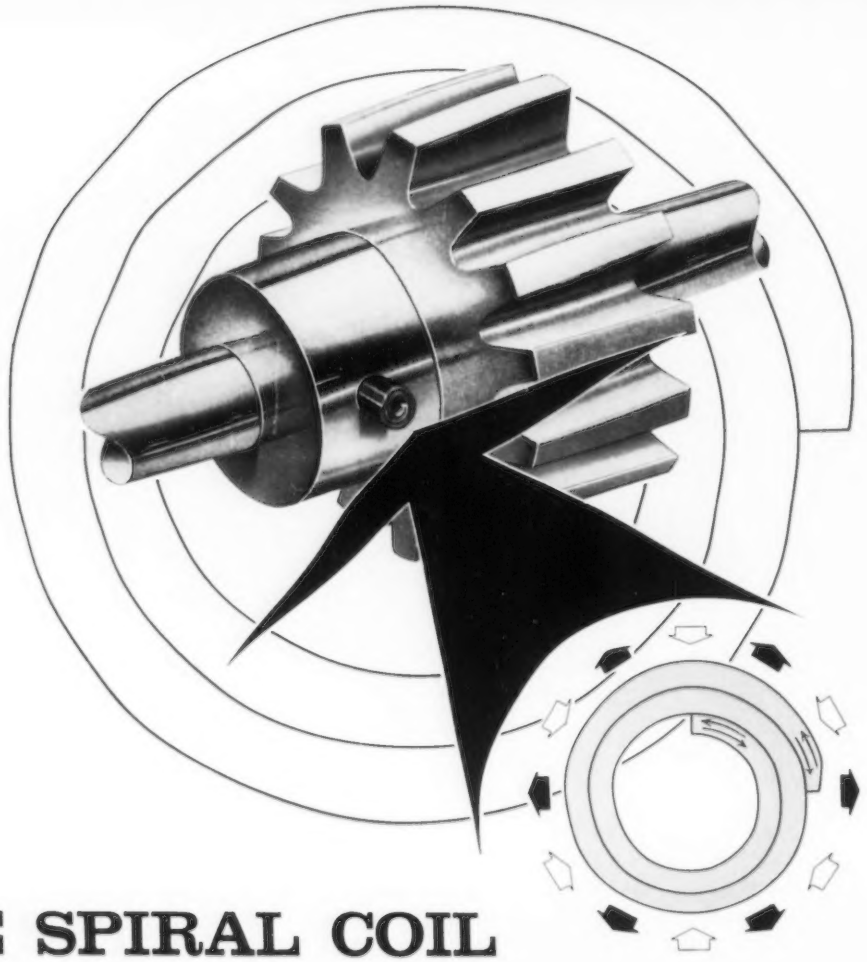

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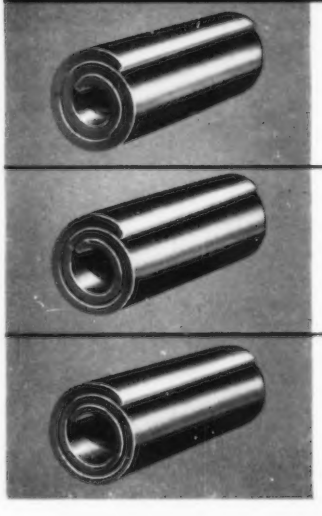

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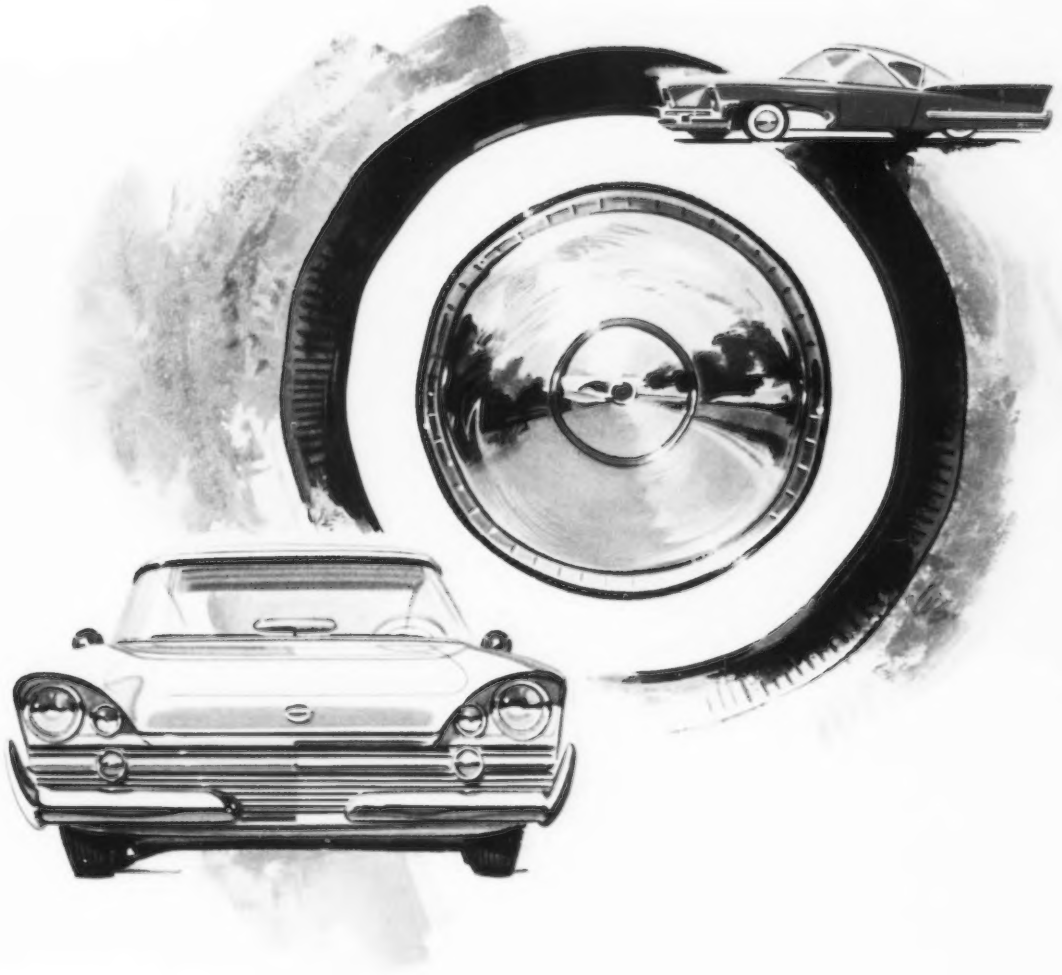

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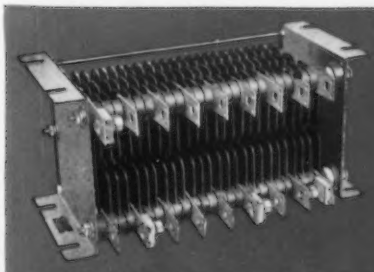

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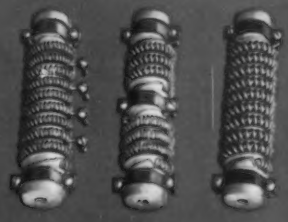

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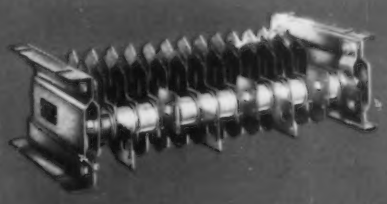

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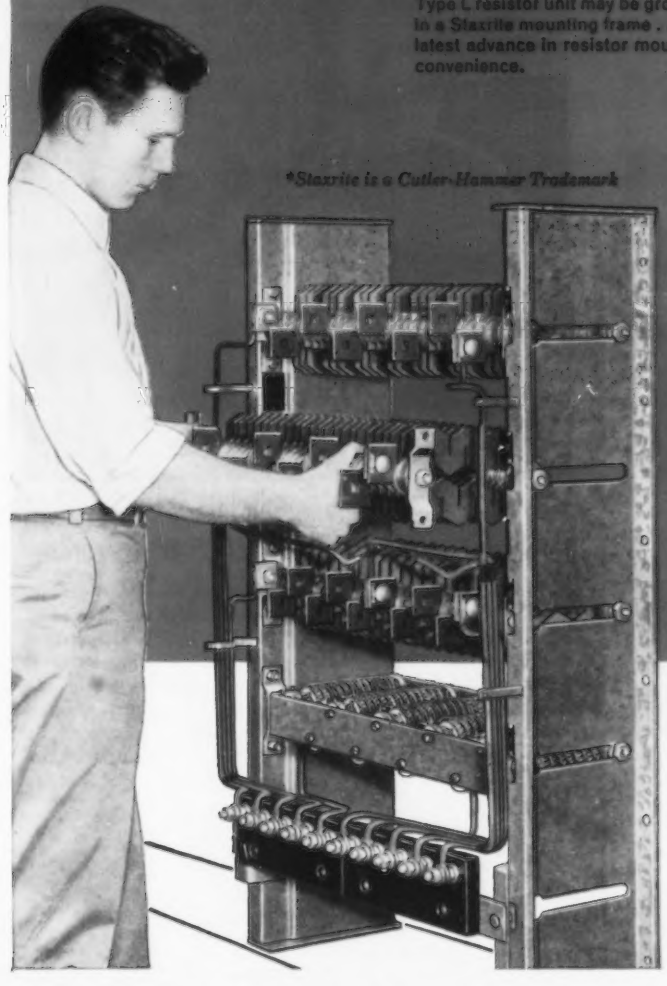

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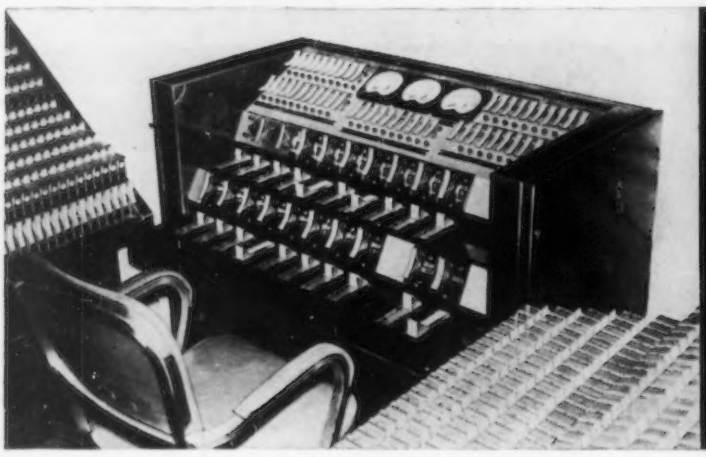
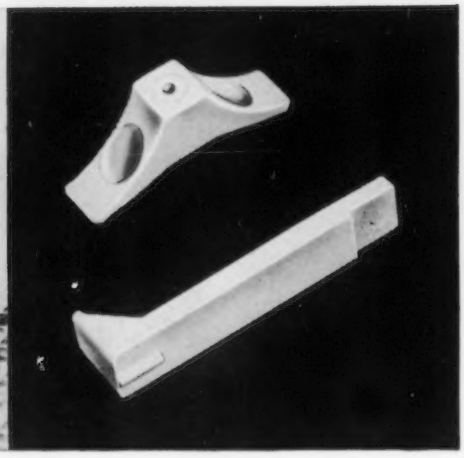
CYANAMID

PLASTICS NEWSFRONT





Plastic Keys Conduct an Orchestra of Light

One operator can play infinite variations in stage-lighting effects on the plastic "keys" of the Lumitron Lighting Control System. Control handles and slide bars are molded of BEETLE® urea plastic, an excellent dielectric which requires no insulation. Permanent, molded-in colors permit quick circuit identification. Developed by Metropolitan Electric Manufacturing Company, the Lumitron has an excellent record of performance.

"Five-in-One" Counter-Top Appliance Features CYMEL® Plastic Accessories

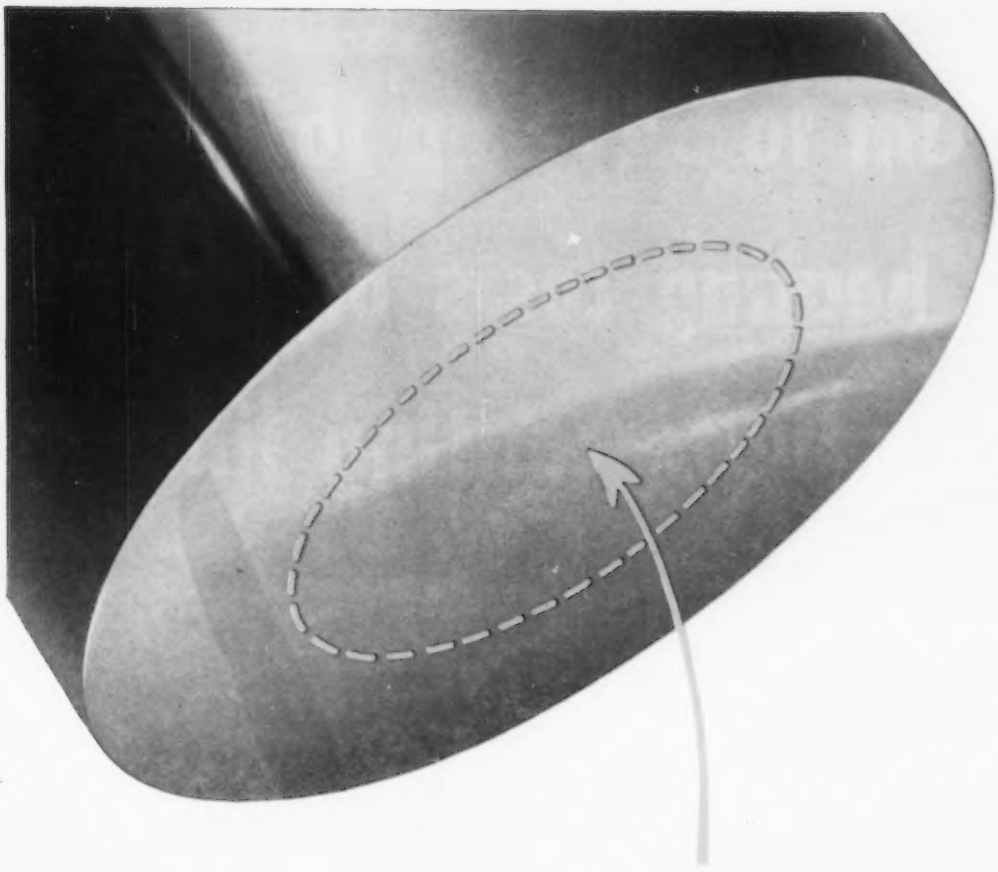
The new multipurpose NuTone Food Center operates a mixer, blender, meat grinder, knife sharpener and fruit juicer from one motor that can be set flush in a counter top Counter clutter, tangles of electric cords and heavy separate appliances are eliminated. A gleaming white 3½-quart bowl made of CYMEL melamine molding compound serves the mixer and juicer. CYMEL makes the bowl lightweight, dent-proof and easy to handle. The bowl is molded for NuTone, Inc., by Prolon Plastics Division of Prophylactic Brush Co.

New Insulated Beverage Set Joins Growing List of Boilable CYMAC® Housewares

Suitable equally for hot or cold beverages, these new double-shelled Thermo-Serve tumblers and pitchers are molded of CYMAC 201 methylstyrene, Cyanamid's new heat-resistant thermoplastic. This CYMAC ware resists staining by fruit acids, coffee and other beverages, and can be washed in boiling hot water, even in automatic dishwashers, without cracking or warping. All parts are injection-molded by NFC Engineering Company and sealed together under heat.

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
40A Rockefeller Plaza, New York 20, N. Y.
In Canada: North American Cyanamid Limited, Toronto and Montreal
Offices in: Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Detroit
Los Angeles • New York • Oakland • Philadelphia • St. Louis • Seattle

CYANAMID Plastics and Resins Division



Here's where hollow parts makers can find new savings

IF YOU'RE boring out bar stock to make hollow parts, you can save money, time and steel. Start with Timken® seamless steel tubing because:

1. YOU SAVE THE COST OF DRILLING; the hole's already there. Finish boring becomes your first production step.

2. YOU SAVE MACHINE TIME by eliminating this costly, original boring operation. You free screw machine capacity for other jobs, increase machining stations *without* adding machines.

3. YOU SAVE STEEL BY WASTING LESS and using more of the steel you buy. You get more parts per ton of steel, because there's less metal to hog out.

And you get finished parts of better quality from Timken seamless steel tubing. We forge a solid round over a mandrel, thoroughly working the metal inside and out. This rotary piercing operation gives seamless tubing its fine forged quality and unvarying spiral grain flow. Precise control of temperature and piercing speed helps assure you of uniform quality from tube to tube, heat to heat, order to order.

To save even more steel, have our engineers recommend the one most economical tube size for your hollow parts job. We'll guarantee it to clean up to your finish dimensions. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN *Fine Alloy* **STEEL**

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Want to SAVE up to 70% of heating costs on your phosphate coating line?

new Parker Cold Bonderite System does it!

Turn down the heat! Put most of your Bonderite line heat costs back in the till! Parker Rust Proof Company has developed a new Bonderite system for low temperature operation.

It includes a new cold alkaline cleaner that works beautifully at 70° and is effective in a temperature range from 60° to 120°. A new Spra-Bonderite, specially formulated to produce a superior coating at low temperatures, has been developed to work in conjunction with the new Parker cold cleaner.

With the new cold Bonderite system, savings are really sizable. Heat consumption in the line is cut by as much as 70%. Cost of the new Parker system is approximately equal to conventional alkali cleaners and phosphate coating chemicals, so the savings in heat are practically all velvet. It is estimated that on an average automobile body line the savings in steam costs can run as high as 10 to 12 cents per body; on an average refrigerator line 4 to 5 cents per cabinet. Savings in B.T.U.s can mean savings in dollars.

The new cold Bonderite system has been production-tested in mass production plants. Its performance has amazed the experts. It's ready to go to work in your plant, saving you money, right now!

Why go on paying for heat you don't need? Start using Parker's new cold Bonderite system. A letter or phone call will bring a Parker man with full, money-saving details.

*Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

PARKER RUST PROOF COMPANY
2179 E. MILWAUKEE, DETROIT 11, MICHIGAN

Since 1914 — leader in the field

BONDERITE corrosion resistant paint base

BONDERITE and BONDERLUBE aids in cold forming of metals

PARCO COMPOUND rust resistant

PARCO LUBRITE wear resistant for friction surfaces

TROPICAL heavy duty maintenance paints since 1883

NEW, COMPACT Century 48-FRAME Fractional HP MOTORS

INDUSTRIAL QUALITY for all applications

take less space...
weigh less...
perform better!

ROTOR

Rotor bars, end rings, and fans integrally pressure-cast of virgin aluminum. Rotors dynamically balanced to very close limits; meet strict quiet-motor requirements.

INSULATION

Heavy vinyl acetal insulated wire, tough mechanically, thermally, and dielectrically, has excellent moisture resistance, highest uniformity. Stator core slots lined with cells of DuPont Mylar bonded to all-rag electrical paper.

BEARINGS

Sleeve: pressed into place in bracket which has been bored true in single set-up operation. Finish boring operation assures proper bearing surface and concentricity. *Ball:* single-shielded, precision fitted in brackets.

LUBRICATION

Sleeve bearing type: wool yarn wicking provides constant oil supply to oil groove. Inner sump cup retains excess oil which is tapped by felt wicks extending into the wool-yarn. *Ball bearing type:* standard construction permits re-greasing.

GOVERNOR and SWITCH

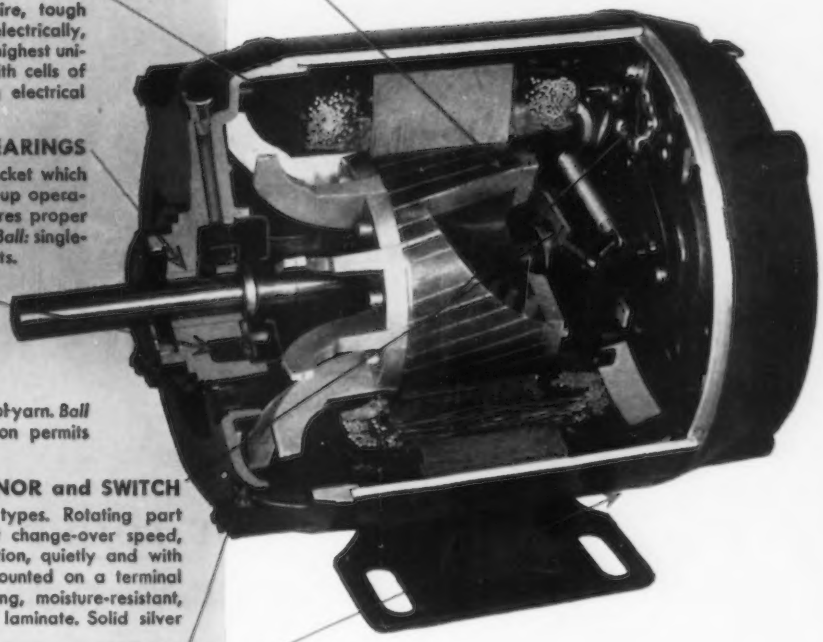
For capacitor and split phase types. Rotating part securely press-fitted to shaft. At change-over speed, governor operates with snap action, quietly and with no flutter. Stationary switch is mounted on a terminal plate; plate is GLASTIC, a strong, moisture-resistant, arc-resistant glass-filled polyester laminate. Solid silver contacts are used.

BEARING BRACKETS

Pressure cast in special aluminum casting alloy. Stress relieved for permanent stability. Strong internal ribbing for strength, and smooth outside surface.

FRAME

Stator frame rings formed of one-piece heavy rolled steel. No frame openings; windings fully protected. Rabbet fit faced and bored true to provide proper alignment of bracket and a concentric air gap. Heavy formed steel feet welded to frame ring.



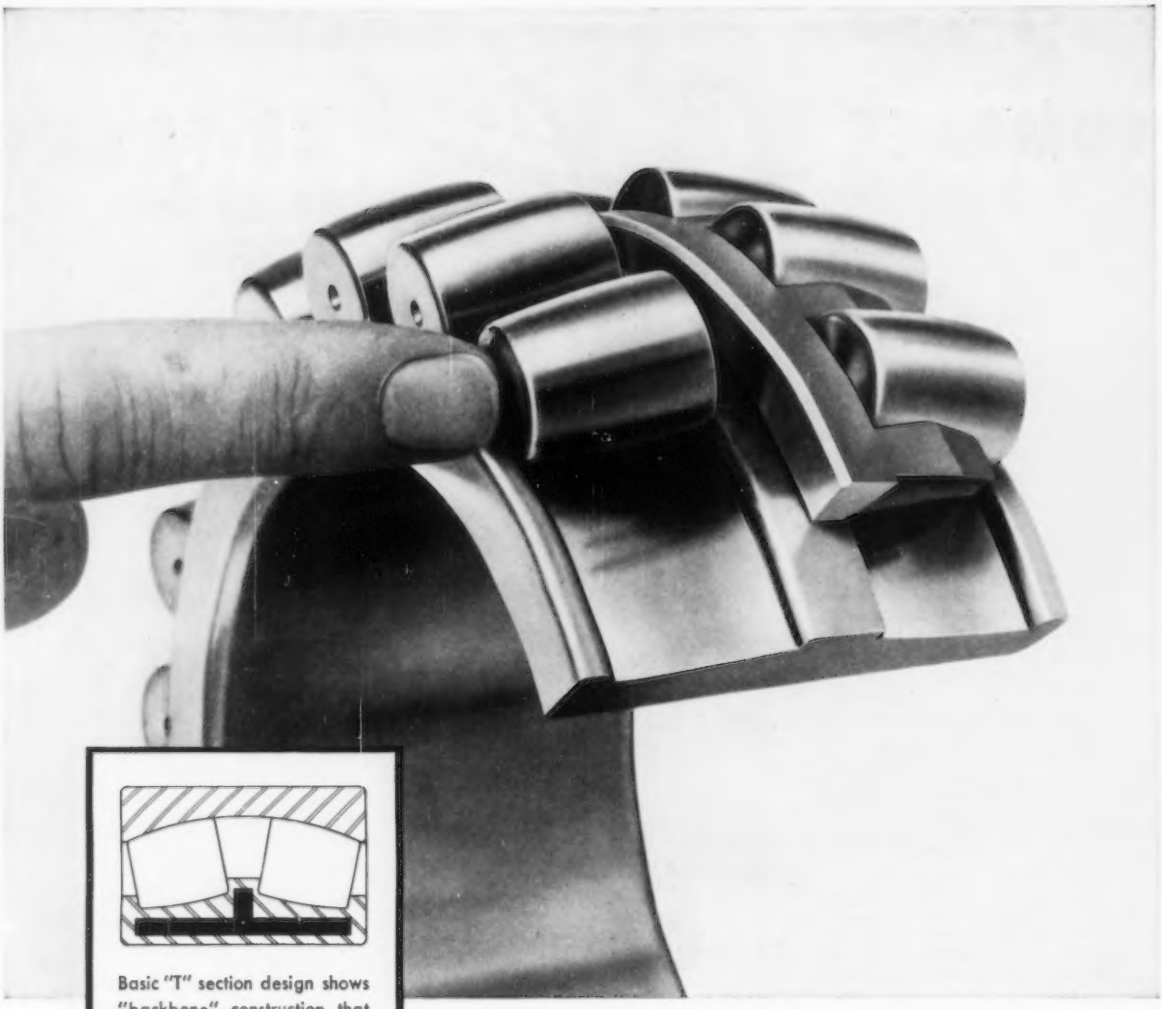
Century Industrial Quality means *design* that does not compromise dependability to gain slight cost advantages... sturdy construction provides the stamina which assures continuous operation. 48-Frame Motors now available from 1/20 to 1/3 HP... Performance-Rated to your needs... with weight savings up to one-third!

Test one of these motors for yourself. Call or write your nearby Century District Sales Office or Authorized Distributor. Send for new bulletin 1-1P1.

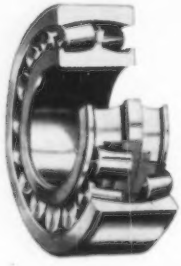
Performance-Rated© MOTORS
1/20 to 400 HP

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*



Basic "T" section design shows "backbone" construction that insures positive roller guidance and stability without skewing under all load conditions.



For roller stability...

there's nothing like "the bearing with the backbone"

The only *positive* way to guide rollers is by an integral center guide flange—backbone of the *Torrington* Spherical Roller Bearing. No floating ring can match it for stability under heavy radial and thrust loads.

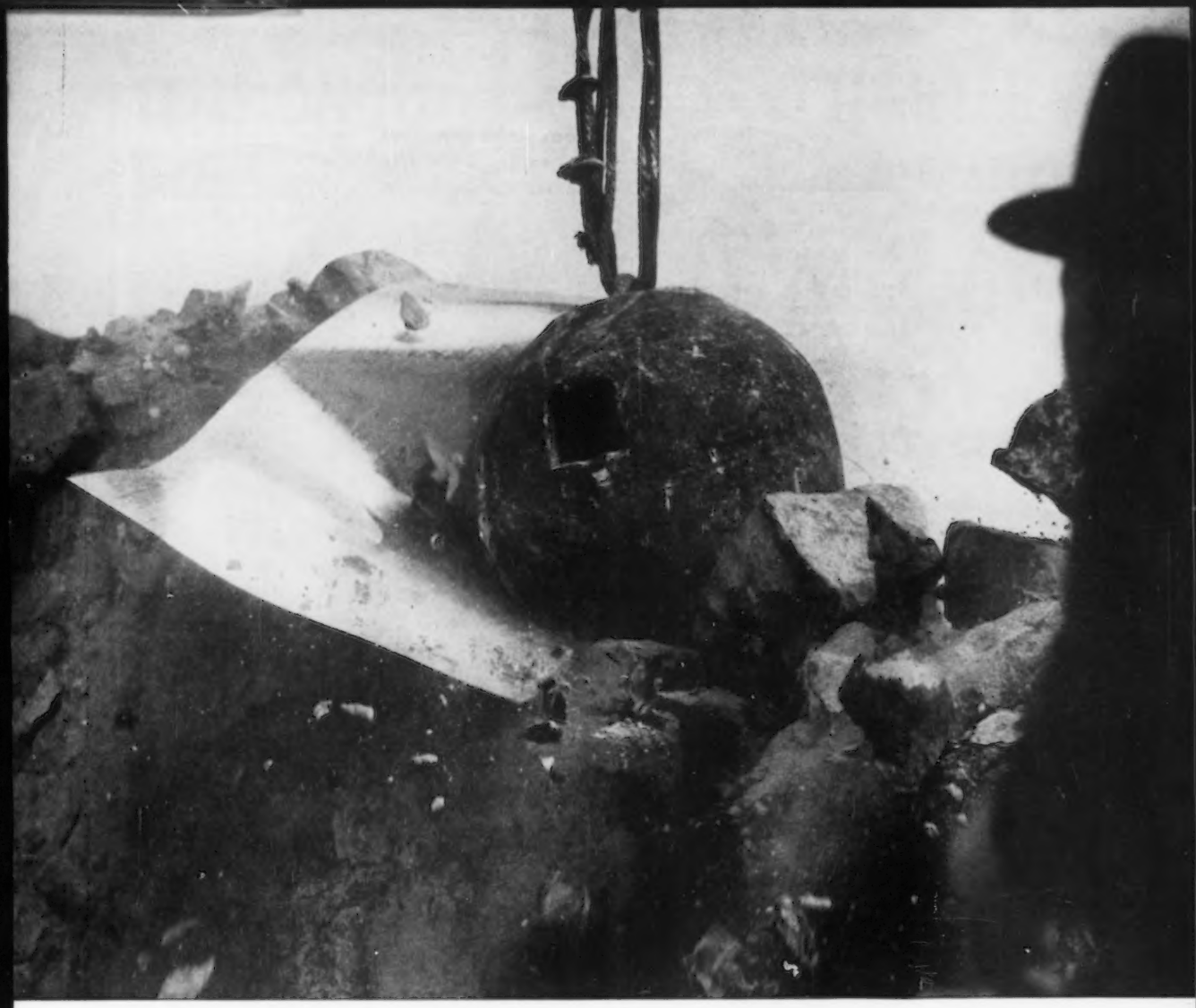
This "bearing with the backbone" insures true rolling motion . . . prevents stress concentration . . . means minimum friction. It makes possible open-end cage design, too, with no shrouds to impede circulation of lubricant to bearing contact surfaces. There is less heating and more positive lubrication.

The integral center guide flange is adapted from the same principle used in the design of Torrington Tapered Roller Bearings. This refinement is typical of Torrington's uncompromising engineering that assures you the ultimate in bearing performance. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST



THEY SMASHED INTO THAT WEIRKOTE® TILL WE COULDN'T STAND IT!

When a half-ton steel wrecking ball smashes broadside on target—mister, that's a *test*.

Yet, when Weirkote zinc-coated steel is put through that, or equally brutal punishment, the zinc remains an integral part of the steel.

Think of that demonstration in terms of *your* products, production steps and cost problems.

Weirkote, made by the continuous process, can be worked to the limits of the steel itself—spinning, deep drawing, roll forming, extrusion. And there's no flaking or peeling.

With Weirkote, you can eliminate the cost of plating, painting or re-dipping after fabrication. And now, Weirkote is treated to inhibit wet storage (white oxide) stain.

Free Weirkote Booklet

Send for the new booklet on Weirkote today. Write Weirton Steel Company, Dept. D-6, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

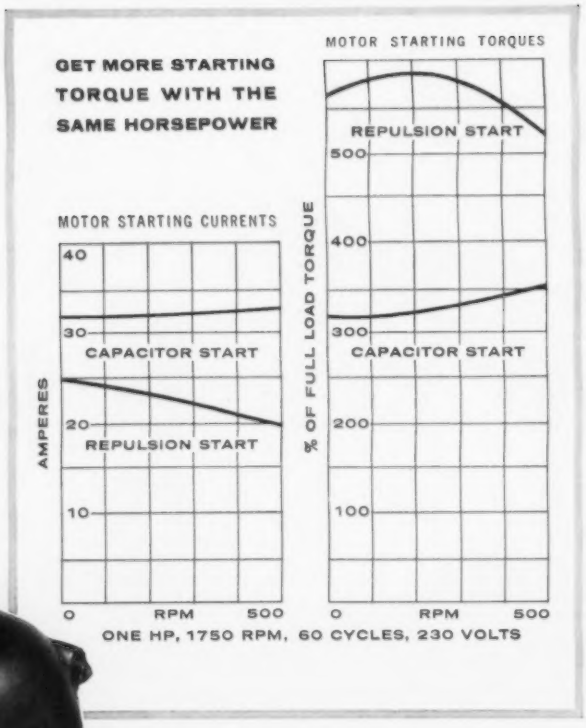
WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

WAGNER SINGLEPHASE MOTORS

This two-in-one motor is your best choice FOR HARD-TO-START LOADS



H. P.	OLD FRAME SIZE	PRESENT FRAME SIZE
1	203	182
1½	204	184
2	224	213
3	225	215
5	254	254U

Integral ratings, 1-5 hp are available in the latest NEMA Frame Sizes

4 pole (1750 RPM, 60 cycle and 1450 RPM, 50 cycle) ratings are interchangeable in mounting dimensions with capacitor start motors of the same ratings.

The Wagner Heavy Duty Type RA Repulsion-Start Induction Motor offers:

- *HIGH STARTING TORQUE*
- *LOW STARTING CURRENT*
- *HIGH OPERATING SPEED*
- *FLAT EFFICIENCY CURVE*

The Wagner Type RA is the work horse of the singlephase motor field. It combines high starting torque for quick, easy starts with low starting current and minimum light flicker. It has a constant high operating speed, even under overload, and a flat efficiency curve over a wide operating range.

You practically eliminate service problems when you power tough singlephase applications with Wagner RA Motors. They have unmatched ability to start high inertia or heavy friction loads repeatedly and they give many years of unfailing service.

Let a Wagner Sales Engineer show you how these motors can be applied to your needs. Call the nearest branch office, or write for Bulletin MU-220.

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

WH58-2

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation
6406 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

TENSION - TO KEEP YOUR BOLTED ASSEMBLIES TIGHTER LONGER

Wherever products are subject to movement, vibration, stresses and strains, more than tight fastenings are necessary to keep assemblies tight indefinitely. There must be constant tension in the assemblies and the one sure way to accomplish this is by the use of famous Reliance Spring Lock Washers. They not only retard "nut creep," but automatically compensate for bolt stretch, thread wear, expansion and contraction due to temperature changes.

Made of cold drawn spring steel in Reliance's own cold finished mill, the Spring Lock Washers are quality controlled throughout their manufacture and offer the reactive range and pressure necessary to keep bolted assemblies tighter longer. Reliance Spring Lock Washers have proved for fifty years an accepted standard in industry, and are produced in four standard series: light, medium, heavy and extra heavy for each screw and bolt size.

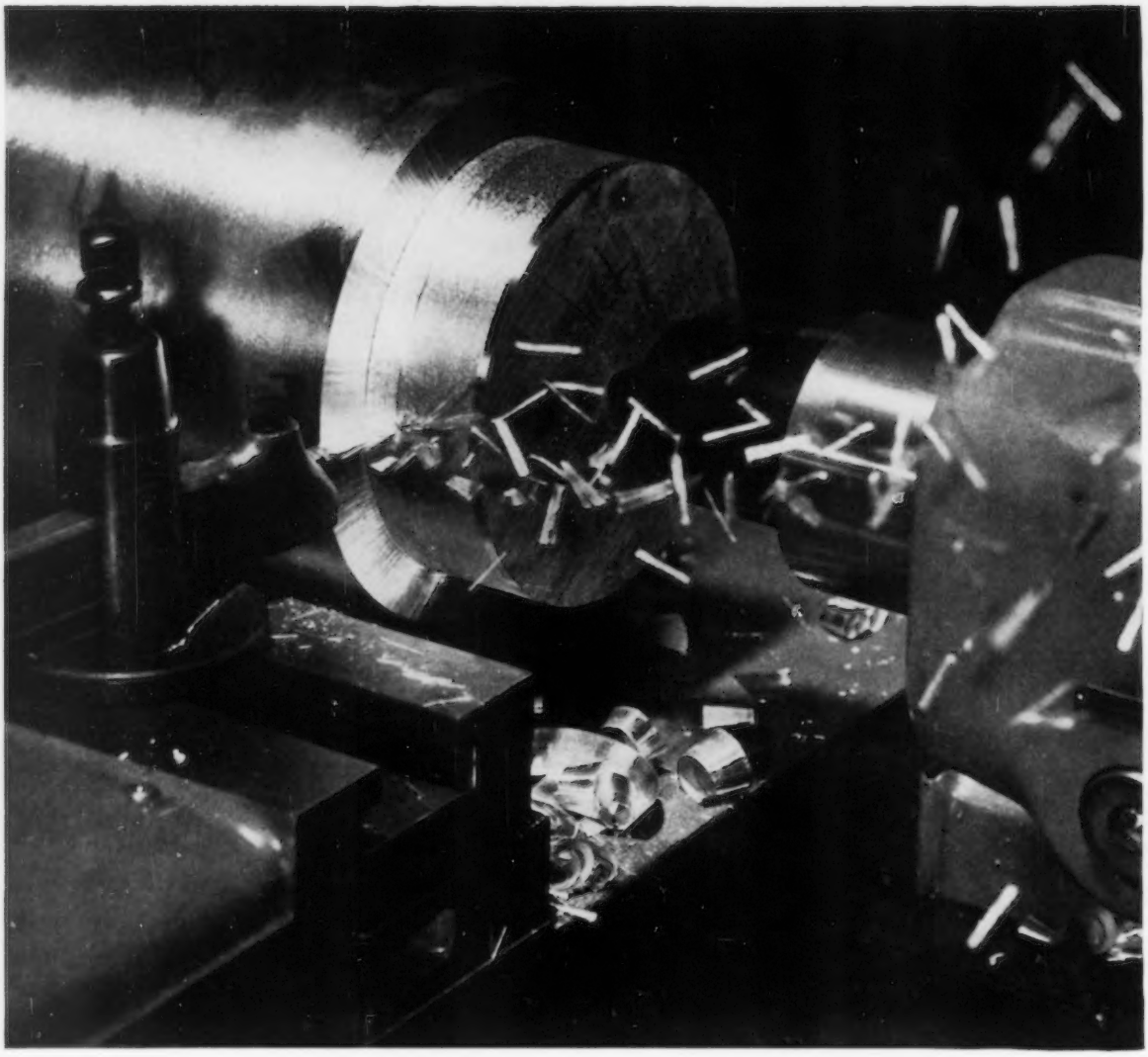
For more information please write for Engineering Bulletin W-50 or request a visit from one of our fastening engineers.

EATON

RELIANCE DIVISION
MANUFACTURING COMPANY
513 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers



Speed! Of all structural metals, Magnesium costs less to machine

In the picture above, a lathe is making a roughing cut of 0.800" in an eight inch magnesium billet. The feed is 0.030 inches per revolution at a speed of 630 feet per minute. In finishing operations, cuts of 0.500" can be made with a feed of 0.003 ipr and a speed of 5,000 fpm.

That's real speed and efficiency—the kind you can always expect when you machine magnesium. This remarkable metal can be milled, drilled, sawed, reamed, bored, planed, tapped and threaded faster than any other structural metal!

Faster machining means easier machining and lower cost machining. It means more production per hour and per dollar, and longer tool life.

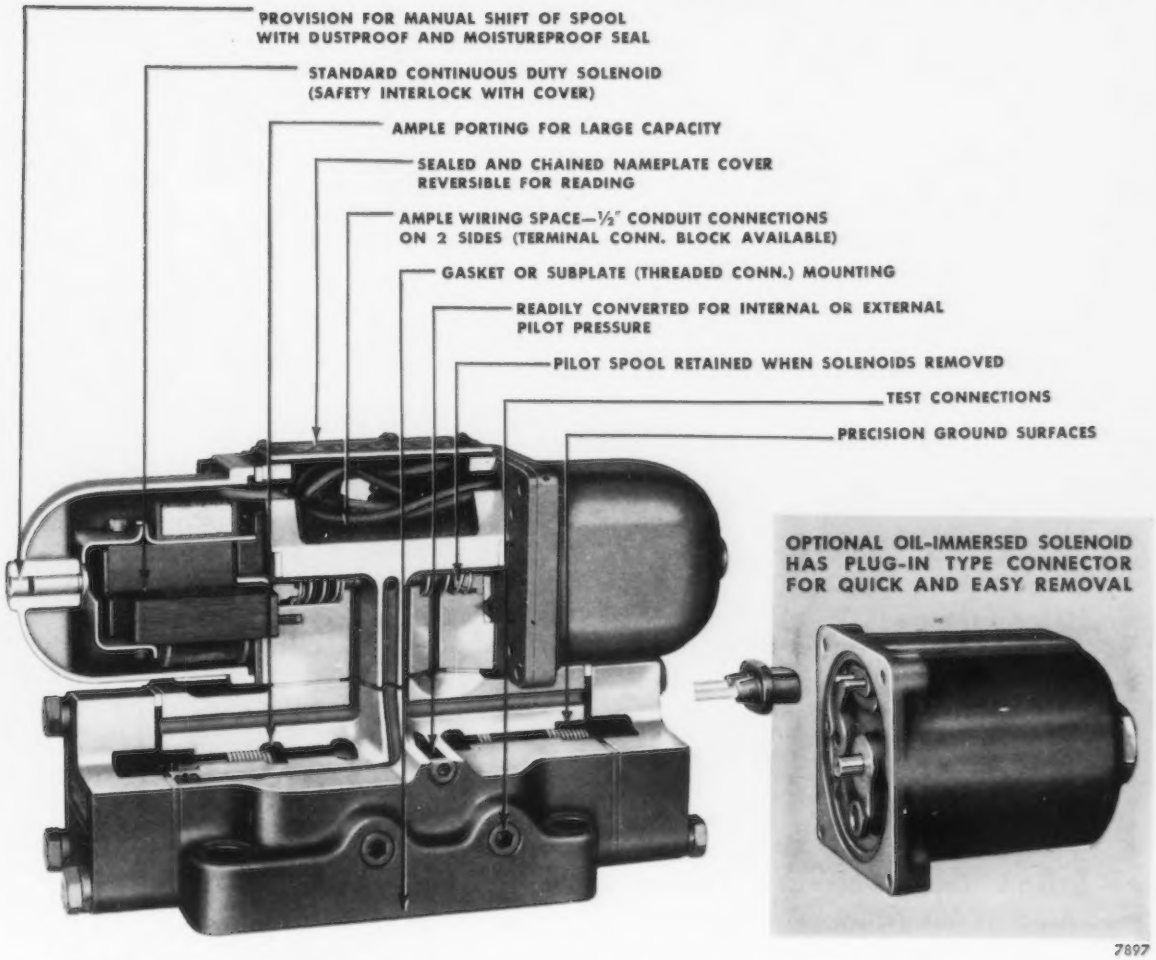
The following table shows how well magnesium compares to the others:

METAL	RELATIVE MACHINABILITY
magnesium	1.0
cast aluminum	1.8
brass	2.3
cast iron	3.5
rolled aluminum	5.0
mild steel	6.5

Let us give you more information about the machinability of magnesium. Contact the nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan, Dept. MA 1404H-1.

YOU CAN DEPEND ON DOW

Only VICKERS® DIRECTIONAL VALVES Have *All* These Features


PROVISION FOR MANUAL SHIFT OF SPOOL WITH DUSTPROOF AND MOISTUREPROOF SEAL
STANDARD CONTINUOUS DUTY SOLENOID (SAFETY INTERLOCK WITH COVER)
AMPLE PORTING FOR LARGE CAPACITY
SEALED AND CHAINED NAMEPLATE COVER REVERSIBLE FOR READING
AMPLE WIRING SPACE—½" CONDUIT CONNECTIONS ON 2 SIDES (TERMINAL CONN. BLOCK AVAILABLE)
GASKET OR SUBPLATE (THREADED CONN.) MOUNTING
READILY CONVERTED FOR INTERNAL OR EXTERNAL PILOT PRESSURE
PILOT SPOOL RETAINED WHEN SOLENOIDS REMOVED
TEST CONNECTIONS
PRECISION GROUND SURFACES
OPTIONAL OIL-IMMERSED SOLENOID HAS PLUG-IN TYPE CONNECTOR FOR QUICK AND EASY REMOVAL
7897

REDUCED DOWN-TIME
LONGER SOLENOID LIFE
LESS MAINTENANCE
EASIER INSTALLATION

Vickers hydraulic 2- and 4-way valves provide the optimum in directional control. They are compact, versatile, and are designed for heavy duty, continuous and rapid cycling operation on all types of industrial machinery. More than a decade of application experience and years of research and development back all the valves' features.

Seven spool types satisfy a wide variety of circuit needs and operate at pressures to 3000 psi. Optional oil-immersed solenoids operate cooler, increasing service life 20 to 30 times.

Installation is simplified with ease of wiring and a minimum of piping. The valves are available for gasket or sub-plate mounting. Mounting position is unrestricted except in "no-spring" models. The optional oil-immersed solenoid has a plug-in type connector and is available in all standard voltages. Field modification of existing units can be made to incorporate heavy-duty, oil-immersed solenoids.

The valves conform to JIC Standards and are available in ⅛" and ¼" direct solenoid operated models . . . ¾", 1¼", 2", and 3" solenoid controlled pilot operated models. These valves cover the flow range from 1.25 gpm to 320 gpm.

For further information, write for Installation Drawing I-182412.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1454 • Detroit 32, Michigan

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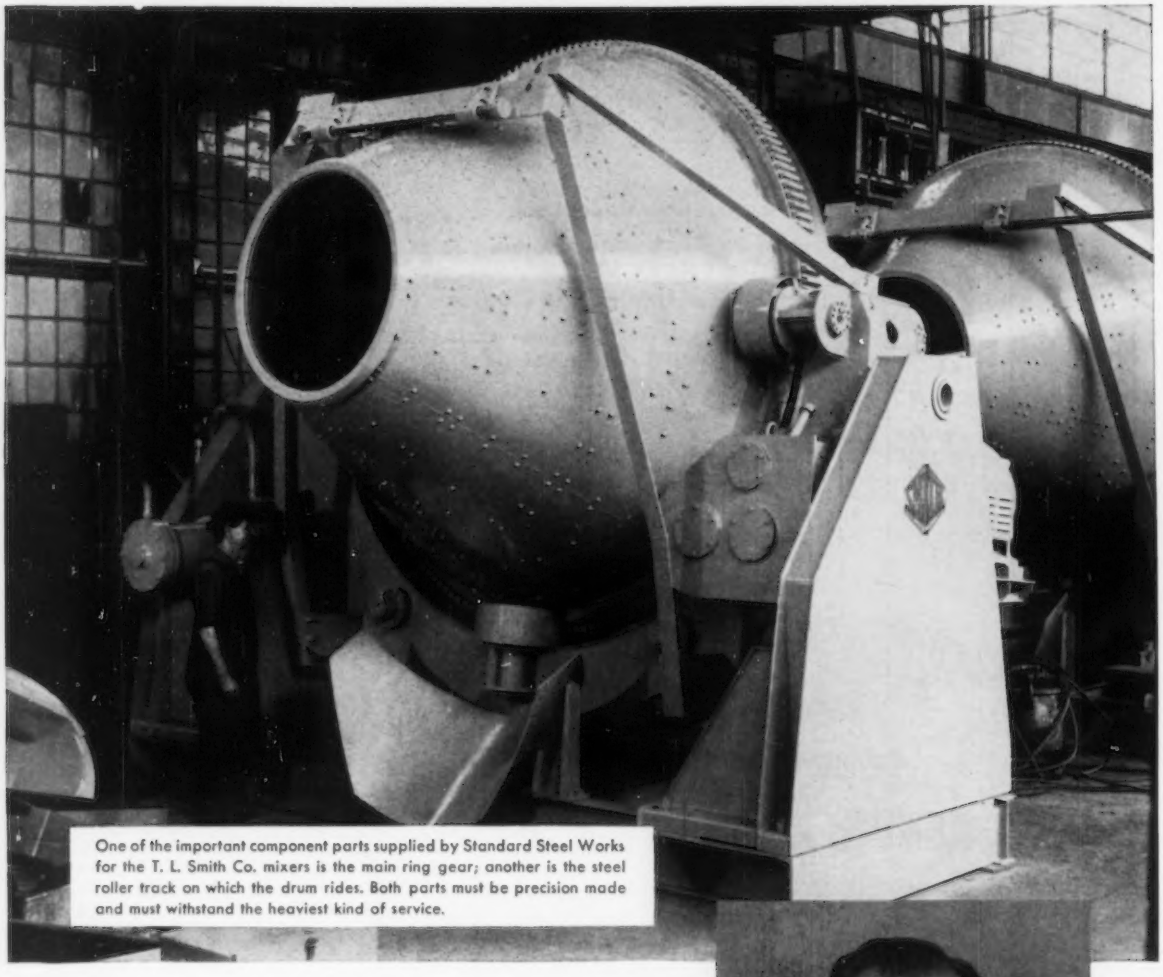
FACTORIES ALSO IN AUSTRALIA, ENGLAND AND GERMANY
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto and Montreal



One of the important component parts supplied by Standard Steel Works for the T. L. Smith Co. mixers is the main ring gear; another is the steel roller track on which the drum rides. Both parts must be precision made and must withstand the heaviest kind of service.

"The T. L. Smith Co. is constantly seeking design improvements and production economies. Standard Steel Works has proved a big help to us in both respects."

As suppliers of component parts to the T. L. Smith Co.—world's oldest and largest manufacturer of concrete mixers —we have made it *our* business to get to know *their* business well enough to consider ourselves a part of their team.

It is our policy to work in the closest possible cooperation with all of our customers to assure maximum quality at lowest possible cost. Let us discuss your casting and forging needs with you. You'll find that service to our customers is as important as the quality of the products we make. Write Dept. 4-A.

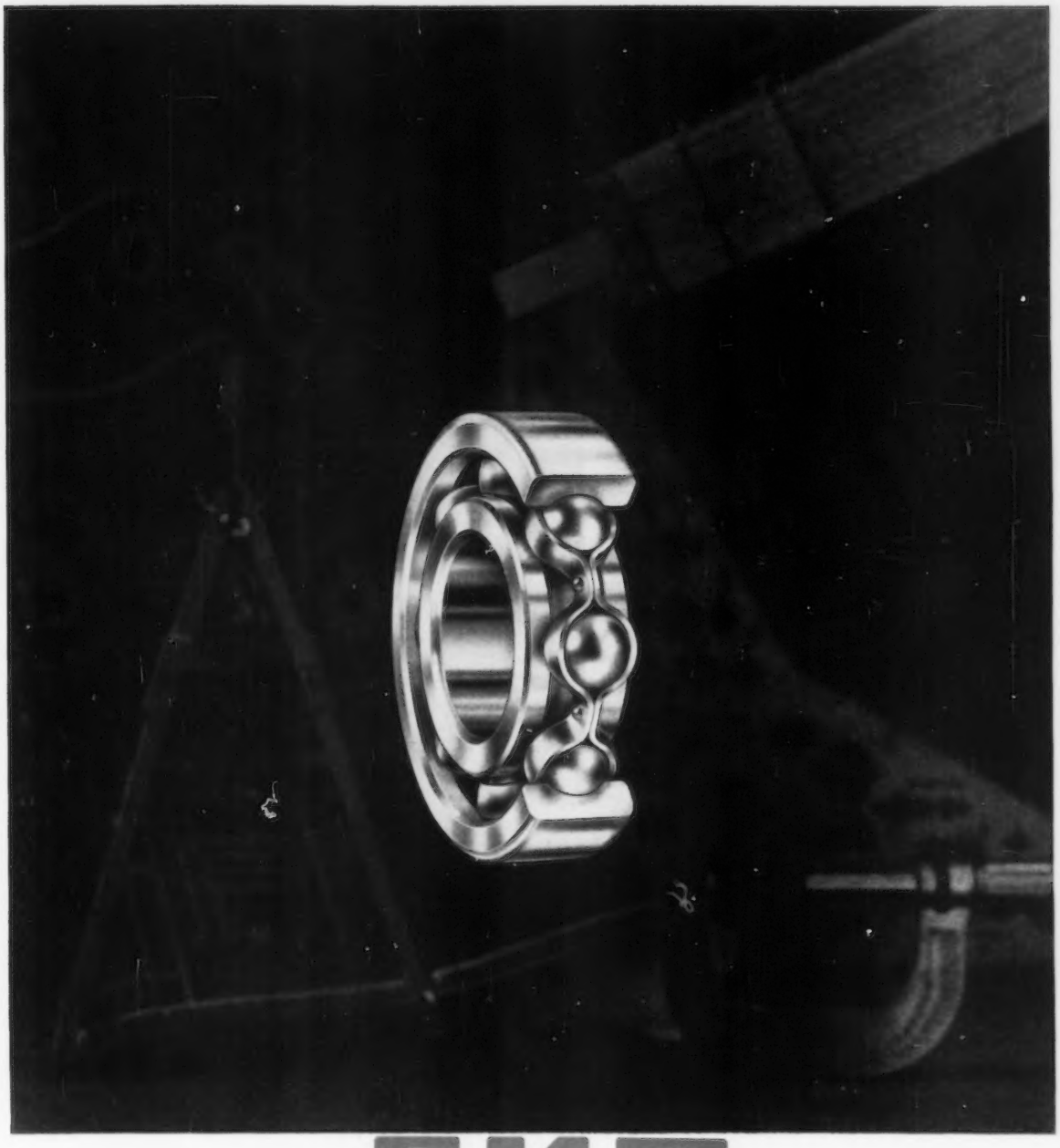
"We are particularly impressed with Standard's methods-people and the way their engineers so effectively supplement our own in constantly suggesting design improvements and production economies," says R. R. Kupfer, purchasing agent for the T. L. Smith Co., Milwaukee, Wis.

Standard Steel Works Division

BALDWIN · LIMA · HAMILTON

BURNHAM, PENNSYLVANIA

Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes



SKF®

BEARINGS FIT INTO YOUR PLANS

You'll find that high quality SKF anti-friction bearings fit readily into any design. SKF makes a complete line of the four basic types, in over 3,000 sizes, ranging from the smallest to the largest—your best assurance of receiving unbiased advice from experienced SKF engineers. Plan now to simplify the problem of selecting the right bearing for your application. Just call the nearest SKF district office today.

7808

SKF

EVERY TYPE—EVERY USE

Spherical, Cylindrical, Ball, and Tyson Tapered Roller Bearings

Tyson Reg. U.S. Pat. Off.

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

For BETTER CONTROL of FLUIDS...

Specify *Norgren* CONTROL VALVES

DIAPHRAGM TYPE VALVES

Automatically protect against damage from excessive pressure build-up. Provide controlled operation for fluid recirculating systems.

Easily adjusted to relieve at desired pressure. Relief settings: 0-15 psi, 0-50 psi, 0-75 psi, 0-125 psi, 0-250 psi for pipe sizes ⅛" through ½", and 0-15 psi, 0-50 psi, 0-75 psi, 0-125 psi for ¾" and 1" pipe sizes.

POP SAFETY VALVES

Prevent the build-up of dangerous, excessive pressures in air tanks. Valve automatically pops open at desired setting. Pipe sizes ⅛", ¼", ⅜" and ½".

LOW FLOW RELIEF VALVES

Small, inexpensive valves suited for a wide variety of uses requiring relief at low rates of flow. ⅛" and ¼" pipe sizes.

FLOW CONTROL VALVES,
Two-Way—Single-Way

For accurate control of air and hydraulic cylinders. Provide large volume flow with low pressure drop, easily and quickly regulated. ¼", ⅜" and ½" pipe sizes.

NEEDLE VALVES

Tapered needle provides controlled metering of air, liquids and gases that do not affect brass. Leak-proof. Choice of five types in ⅛" and ¼" pipe sizes.

For complete information, call your nearby Norgren Representative listed in your telephone directory... or

WRITE THE FACTORY FOR NO. 800 CATALOG

C. A. NORGREN CO.

Wherever Air is Used in Industry

3428 SO. ELATI STREET • ENGLEWOOD, COLORADO

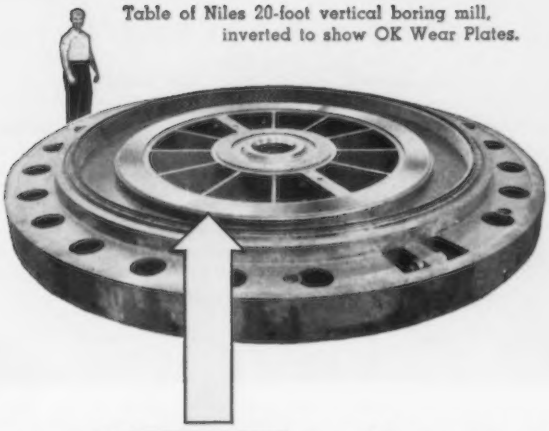
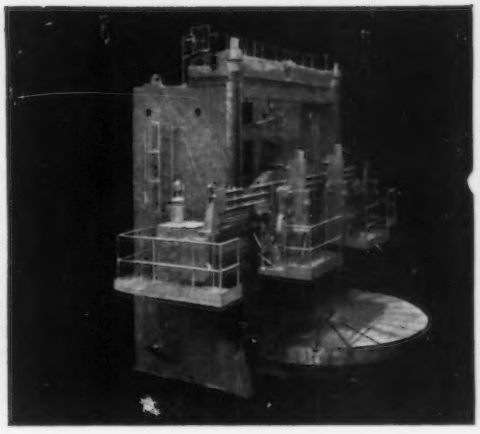
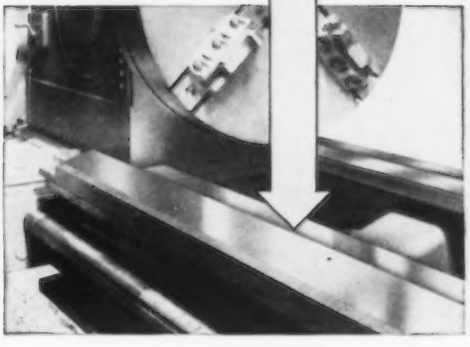
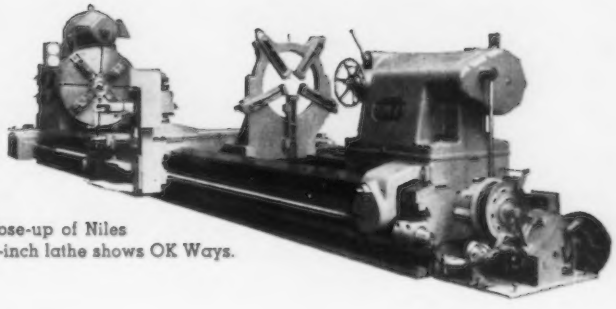


Table of Niles 20-foot vertical boring mill, inverted to show OK Wear Plates.



good ways to keep customers happy





Close-up of Niles 60-inch lathe shows OK Ways.

THE NILES TOOL WORKS . . . of the Baldwin-Lima-Hamilton Corp., is one of many U. S. machine tool builders using OK Hardened Ways and Wear Plates. Their mammoth machine tools require ways and wear plates that maintain absolute accuracy for the life of the machine. OK Ways and Wear Plates are used because our unique manufacturing and hardening processes make them virtually wear-proof.

Special-analysis tool steel is welded to a soft steel backing, resulting in a work surface of high wear-resistant properties. This process permits manufacture in long lengths without danger of bowing or warping.

Hardening is done in electronically-controlled furnaces, giving a ROCKWELL C 64-66 the full depth (normally 3/16") of the tool steel. They are precision ground to tolerances of ± .0002" with low micro-inch finish.

Make your customers happy. Insure trouble-free operation of your machines with OK Ways and Wear Plates (also available in clad aluminum bronze). Our engineering staff will assist you in your design or production problems.

For free bulletin showing seven standard cross sections in over 60 sizes, write Dept. 41-B

THE OHIO KNIFE CO.
CINCINNATI 23, OHIO

Hardened Ways
Slitter Knives
Shear Blades
Cut-Off Blades
Hardened Spacers
Gibs
Ball Races
Work-Rest Blades
Wear Strips
Bronze Ways

The BODINE line—
a complete line of fractional hp motors

Over 3500 standard motors—built to order—only 12- to 16-week delivery

...for blowers, pumps, coin-handling units, communication equipment, therapeutic devices, sound-recording and reproducing equipment, machine tools, and similar applications

BODINE TYPE N MOTORS

These motors are available in three basic sizes... the smallest 3⅜" in diameter... the largest 5½". Almost any type winding. Standard ratings from 1/150 to 1/6 hp at 1725 rpm.

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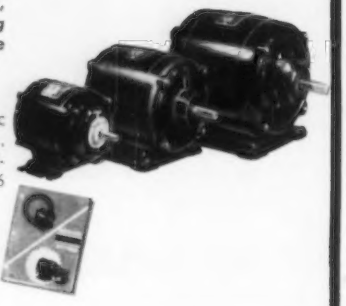

...for instruments, timing devices, control apparatus, and related equipment

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Models with parallel shaft speed reducer have high starting torque of not less than 150% of full load torque at room temperature. Quickly reversible under load. Synchronous or non-synchronous. Drive shaft speeds range from 300 to 0.7 rpm...torque ratings from 1.3 in. oz. to 120 in. oz.

Write for bulletin 1024A
...for speed reducer models, bulletin 1023B

...for use in office machines, automatic phonographs, circulating pumps, air conditioning equipment, and similar applications

BODINE TYPE U MOTORS

"U" type motors are available in 1/20 and 1/15 hp at 1725 rpm...and in 1/30 hp at 1125 rpm. Diameter 4⅜". Split-phase construction. Resilient mounting for quiet operation. Thermal overload protection.

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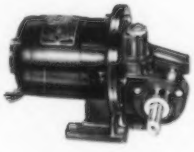
BODINE SPEED REDUCER MOTORS

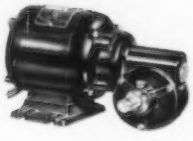
...combines motor and speed reducer in one unit, eliminating all cumbersome and complicated speed reducer transmissions such as belts, gears, and chains

...single or double reduction speed reducers for transmitting low torques over a wide range of speeds. Height, 3⅝".

...double worm-gear reducer to deliver moderate torques at low speeds. Height, 4¾".



...single reduction, right angle worm gear reducer to deliver moderate torques. Height, 4⅞".

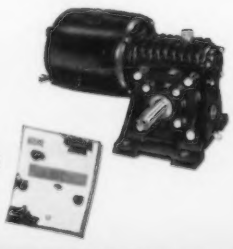


...double worm-gear reducer for transmitting high torques at low speeds. Height, 6⅞".

...single reduction, right angle worm gear reducers for transmitting substantial torques. Height, 6¼".

...heavy duty reducer for continuous driving of heavy loads. Ample reserve for overloads. Height 7⅞". Eight different windings.

Write for bulletin 1022B



PERSPECTIVES

in design and development . . .

Measles and Technology

"The question is frequently asked, 'How does technology affect society?'—in somewhat the same way that one might ask, 'How do measles affect society?', as though technology was a quite extraneous influence."

With this amusing simile, Dr. E. W. R. Steacie, President of Canada's National Research Council in Ottawa, points up a public attitude which he and many of his professional colleagues believe is one of the most potent dangers in our society today. An underlying feeling on the part of many people who are now making decisions that affect the course of nations is that science and technology are somehow demonic inventions issuing from a small band of "uncouth, ungentlemanly" men who have little concern with human nature. And these men are forcing science and technology on an unwilling society that is powerless to modify its effects.

Maybe Yes, Maybe No

Society's attitude is indeed ambivalent, Dr. Steacie goes on. People looking at the medical and material applications of science welcome its advances and call for more scientists and engineers. But as they call for more scientists and engineers they have an uneasy feeling they are spawning a juggernaut. General ignorance of what science is and does shows up in practical politics as unwise secrecy and manpower policies, and has climaxed an irrational reaction to the Russian's Sputnik. The seriousness of the problem as he sees it prompted Dr. Steacie to choose the topic, "The Impact of Society on Science" for the Purvis Memorial Lecture he was asked to deliver in Montreal recently.

The misunderstanding of science has been born, Dr. Steacie believes, out of the failure of education to pass on to presumably educated people a general understanding of its aims and methods. This results in a failure of these people to make a distinction between science and technology or between science and its relation to the humanities and society.

Technology, Dr. Steacie points out, has been with us since earliest times. Crafts developed and were pursued in a traditional fashion for many centuries. A few hundred years ago, as man developed a desire to free himself from tradition, he developed curiosity about nature. He explained processes that were well established. And, as he accumulated more knowledge, he enlarged possibilities for technical change.

Society Controls Technical Change

Actual accomplishment of the technical change is always a definite and deliberate choice of society. And if harm does flow from science and technology, Dr. Steacie avers, it is because society has made an unwise choice. He points out it is technically possible to design longer, more ornate automobiles. Or it is also possible to make them more durable, cheaper, more convenient. The choice is decided by the public under the influence of mass communication. Science reveals what is possible but has only a minor influence on what is done with it. It is offering man the information and knowledge which will give him freedom. Control over disease and fertility makes it possible for man to make effective population decisions. The decision on how to use it lies with society.

Judicious application of science and technology has been hampered, Dr. Steacie believes, by an attitude which describes the "scientist as a man who knows a little about the humanities and is ashamed that he

(Continued on page 49)

utilizing

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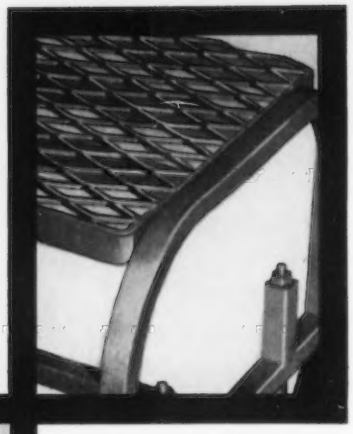
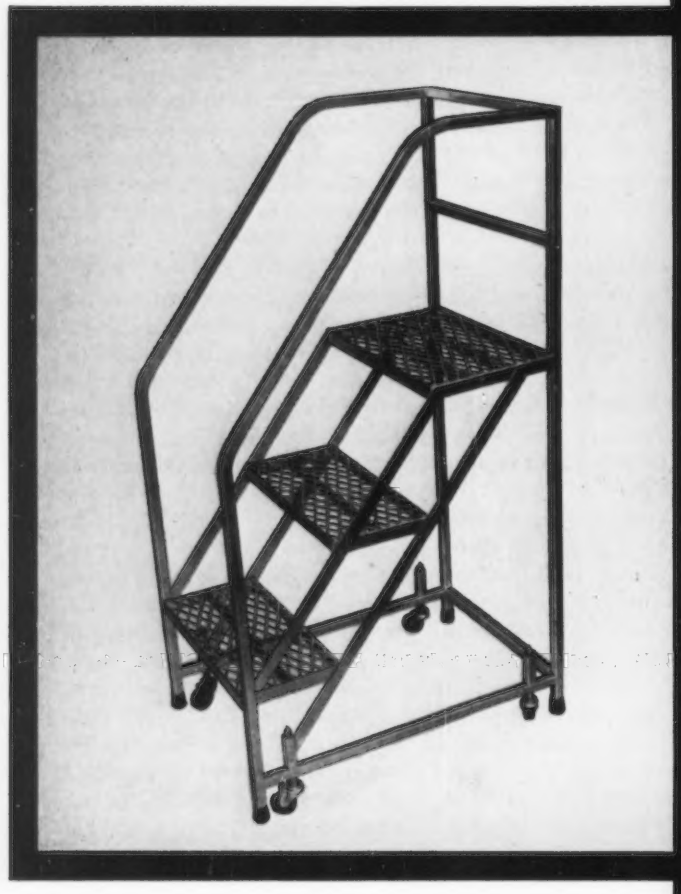
ladder stands are

stronger, lighter, safer





Alco-Lite ladder stands are among the finest made. They handle easily . . . yet are safe, sturdy and stable to step on.

The success of these products owes much to Penmetal expanded metal. Used for treads, the handsome diamond truss pattern contributes importantly to the overall strength of the ladder . . . yet keeps weight to a minimum. Furthermore, the open mesh is exceptionally slip-resistant, and practically cleans itself. Cost: relatively small.

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Alco-Lite steel ladder stands are made in many designs by Aluminum Ladder Co., Worthington, Pa. Treads are Penmetal expanded metal.

METAL MARK Penmetal 1869 OF QUALITY

a name to remember

does not know more, while a humanist is one who knows nothing of science and is proud of the fact." A feeling has grown up that the scientist is a narrow specialist who dips deep into questions that have no real significance for human beings. The humanist on the other hand is broad. He deals with the 'whole man'."

No Narrow Scientists

The argument that scientists are intrinsically narrow and humanists necessarily broad, Dr. Steacie feels, is dubious. A professor of classics is a highly specialized fellow. And whether specialized training in classics or history inevitably turns out a broader product than training in biology is moot. Personal characteristics certainly count more than formal training, in Dr. Steacie's view, and the subject of the specialty, alone, is no basis for counting scientists as second-rate citizens.

The conflict between science and humanities is specious. There are no real clashes between the two, and much of what passes as "appreciation of the arts and letters," Dr. Steacie believes, "is really a combination of antiquarianism and the old snob appeal of a 'gentleman's education' ". As Dr. Conant pointed out when he retired from the Presidency of Harvard, "The humanistic tradition is, in fact, the tradition of the continuing triumphs of the creative human spirit."

These views raise serious educational questions. And they are, also, difficult. Those who will be leaders tomorrow must have some comprehension of the scientist's philosophy and goals. This obviously cannot be accomplished by forcing arts students to study Physics I and Chemistry I. But they should be convinced this is part of the equipment for an educated person. A man who expresses contempt for his environment and all knowledge of it can scarcely claim to be educated.

Against this background of public misunderstanding, Dr. Steacie makes some general observations on the recruitment and education of scientists and engineers in Canada where a shortage is causing considerable concern, as it is here. The solution to Canada's problem, which he feels is somewhat exaggerated, lies in providing generously for educational facilities, so that all students who choose a technical career can be educated. It does not lie in coaxing students away from the humanities. For the progress of science is rooted in the quality of education and not in the quantity of students who brush with it.

Scientific Problems Ignored Until Sputnik

Public reaction over Sputnik's launching, he believes, is the most striking demonstration of the confusion and ignorance over scientific problems of the day. Shock over the Russian technical achievement was the reaction of people who had ignored statements of scientists and engineers for the past 10 or 15 years. The Russians have been putting a sustained 40-yr effort into science and in doing so they were bound to reach parity with the West. Meanwhile Western countries with a large dose of nationalism have erected security barriers which have produced an enormous amount of harm. There are even vaguely comic aspects. Within a few weeks public opinion has swung from a view that the West has superiority in science to one that we are lagging far behind the Soviets. Such extreme views have no underpinnings in reality.

Dr. Steacie is confident that Canadian science with reasonable support will make important strides in the years ahead—provided people achieve a sufficient understanding of its possibilities to pay for it. The Canadian attitude toward science and society as observed by Dr. Steacie undoubtedly has close parallels in this country. The calm wisdom of his words bears attention in this country as well as in his own.

ND FACTS

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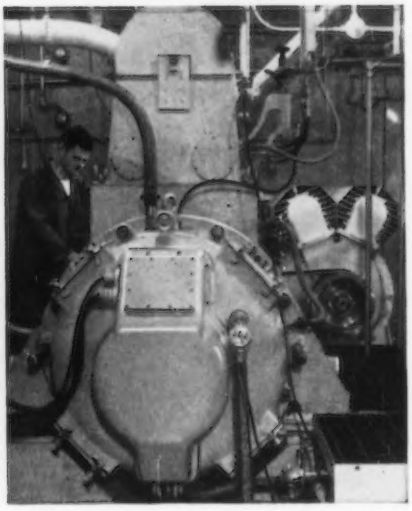
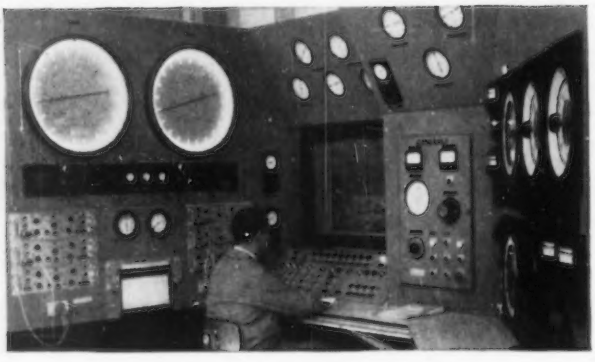


Test stand for running jet engine ball bearings at high speeds, high temperatures under heavily loaded conditions.

RESEARCH NEVER STOPS!



Instrumentation and control console for test stand shown above, for testing full-scale mainshaft ball bearings.

Tomorrow's needs are today's concern at the aircraft ball bearing research facilities at New Departure. For, the future development of the ball bearing will be closely identified with future engine design trends. This means New Departure spares no effort in developing bearings to operate at higher speeds, heavier loads, and under higher temperatures with good bearing-life predictability.

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1908–1958 GM FORWARD FROM FIFTY

ND NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Product Engineering

January 20, 1958

ugly LITTLE FACT

Francis Galton, who invented identification by fingerprints, once told Herbert Spencer that no one could explain the origin of fingerprint patterns—that even fingers of unborn children had them. Spencer insisted that this was going at the problem in the wrong way; that the proper way to begin was to consider the purpose of the ridges, then to work backwards. He went on to explain that it was obvious that the delicate mouths of the sudorific glands required the protection of the ridges on either side.

His developed hypothesis was most ingenious, but Galton finally broke in to explain that the mouths of the ducts were not in the valleys, but along the crests of the ridges. Spencer laughed and admitted, "a beautiful theory, killed by a nasty, ugly little fact."

Every engineer faces this situation periodically. Only recently, one engineer developed a new electromagnetic circuit that made it possible to build and destroy the magnetic field much faster than the older ones do. He had apparently changed the slope of the hysteresis curve, so loading and unloading time for magnetic chucks could be cut. But the old-time shopman who was asked to build the prototype shook his head and said, "It won't be any faster than the old one." The prototype was built, and the old-timer was right—unfortunately.

In another case, engineers decided that the way to arrive at a very accurate aspherical lens was to produce a very accurate mold for the glass. This would avoid the almost impossible task of lapping the lens surface. So they designed, and had built, the necessary "black box" to control a contouring lathe. It wasn't until they set the shopmen to work on the first mold that they found out two nasty, ugly little facts: (1) the lathe couldn't maintain the required accuracy, (2) no one had yet developed a toolbit that could cut chilled iron without wear.

The fact that available materials couldn't stand the heat held up gas turbines for years. The fact that development takes time lost us the satellite race. There are endless other examples that prove the man in the ivory tower must be practical enough to take a periodic look at the foundations, or the tower will collapse. Theory is all right in its place, but it must eventually face up to the nasty, ugly little fact.

K. Langerman

UPDATING THE HI-TEMPERATURE STORY ON . . .

GRAY IRON CASTINGS

CHARLES F. WALTON
Editor, The Gray Iron Castings Handbook

DR. FRANZ R. BROTZEN
Associate Professor, Metallurgy, Rice Institute

JOHN F. WALLACE
Associate Professor, Metallurgical Engineering, Case Institute of Technology

ABOUT THE AUTHORS . . .

Mr. Walton is technical director of the Gray Iron Founders' Society. Through his efforts the society has spent more than $100,000 compiling the invaluable handbook of which he is editor. Formerly, he was with Inland Steel Co., with Meehanite Metals Corp., and with Case Institute as assistant professor.

Dr. Brotzen, in addition to his work at Rice Institute, is consultant to the Naval Research Laboratory and was formerly a physical metallurgist with the U. S. Bureau of Mines.

Mr. Wallace came to Case Institute of Technology after service with the Carnegie-Illinois Steel Corp. and later with Watertown Arsenal where he was director of the Rodman Laboratory.

GRAY IRON—OLD FAITHFUL

Why its widespread use for castings? It offers:

- Low cost
- Excellent machinability
- Complex shapes with thin walls
- Low notch sensitivity
- Enviable wear resistance
- Low shrinking, high rigidity for stable dimensions
- Good compression strength, damping qualities for machine bases.

Tonnage of gray iron outweighs by six times the combined annual total for all other casting materials. But rivals have been making inroads into its popularity when design runs into heat problems. Why?

The trouble has been less with gray iron itself than with inadequate information about it. Too often, another material is specified only because high-temperature facts on gray iron are lacking. The literature shows that its castings show a slight loss in tensile properties from room temperature to 600 F. And rule-of-thumb will allow full design loads up to 800 F. But these figures, reflecting conservatism of the ASTM and ASME codes, do not allow full utilization of this material which, in compression or under low tensile stress, can be and often is used beyond 1500 F. Moreover, the generalizations are not very helpful because different grades of cast irons behave differently at elevated temperatures.

Result: We often turn to other materials for which more complete data is supplied—when cast irons might have been suitable and, perhaps, more desirable.

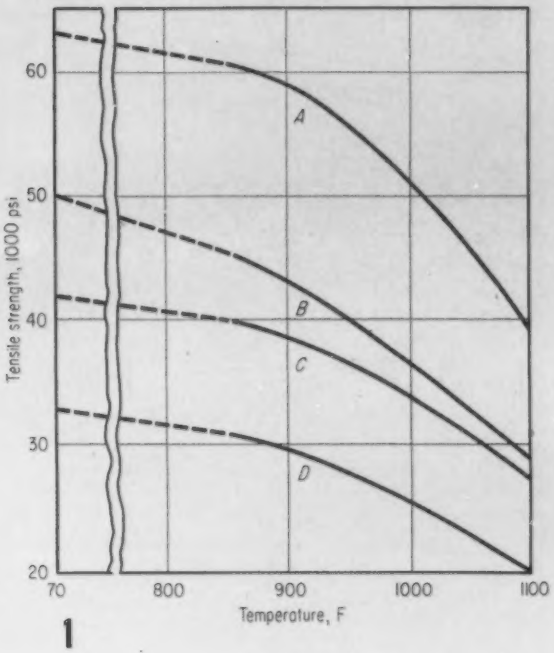
The full story about gray iron is now gathered together. In a project sponsored by the Gray Iron Founders' Society, the authors of this article were assigned to hunt down the data which they will present soon in a single volume, The Gray Iron Castings Handbook. Its contents include properties, machinability, weldability, casting and heat-treating practices, metallurgy and applications. The other cast irons—malleable, ductile or nodular, and austenitic—are also covered. This compilation furnishes the design field what it needs to know—a roundup of time-tested facts modernized with data from more recent research. One section of the book covers gray iron at elevated temperatures—shows when this material can fill the bill under conditions of growing importance in today's technology.

Through cooperation of the Society, this is the section—in a form most useful to the design field—that PRODUCT ENGINEERING is here presenting in condensed form ahead of handbook publication.

I—MECHANICAL PROPERTIES

Tensile strength goes down as rising temperature softens the metal and changes its metallurgical structure, Fig. 1. These changes remain, giving lower strength after the iron is cooled to room temperature. The properties noted are for section thickness of ½ in. —they can drop to from 60% to 70% of these values for sections up to 3 in. Gray irons bolstered with carbide-forming materials like chromium and molybdenum are more stable. At elevated temperatures they retain strength better than unalloyed gray irons.

Thermal cycling, too, can reduce room-temperature properties. Table I shows the effect on tensile strength



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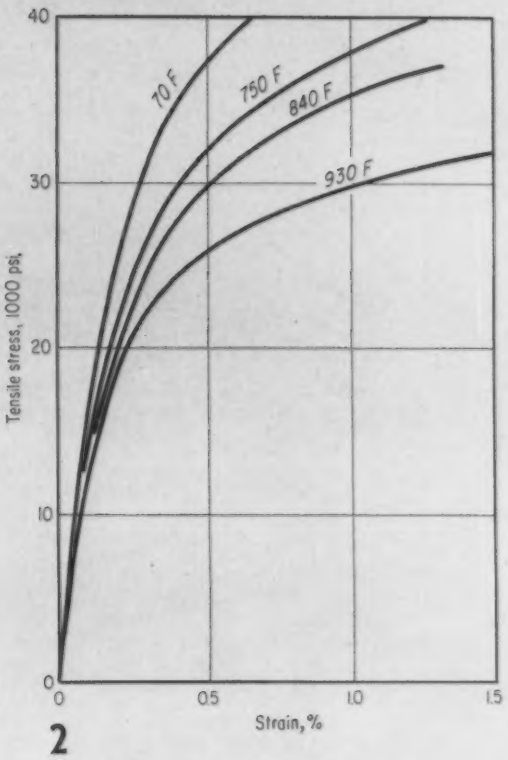

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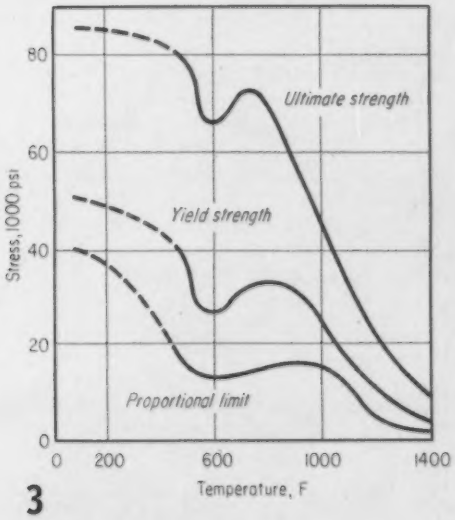

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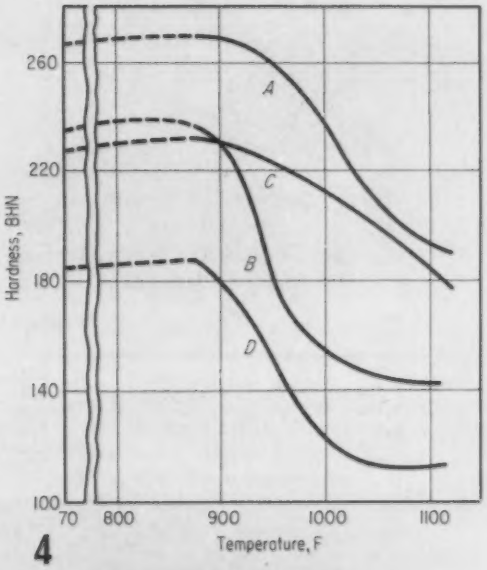


4

1 Tensile properties . . .
of representative gray irons at elevated temperatures.

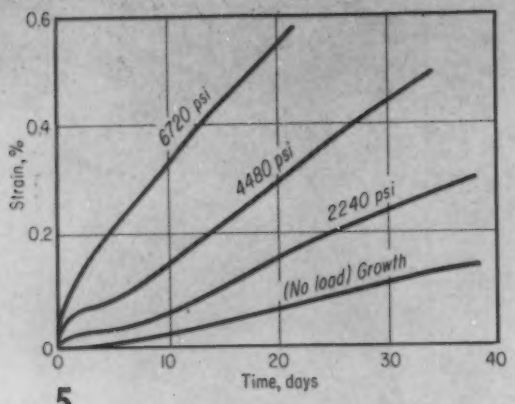
2 Stress-strain to fracture . . .
for a typical class-40 unalloyed gray iron.

3 Compressive properties . . .
of a (class-20) gray cast iron decreases with temperature.

4 Hot-hardness decreases . . .
for these gray irons as temperature goes up.

Table I—Heating 150 times to 1500 F Lowers Tensile Strength of Gray Irons

Alloy Addition, %	Initial Tensile Strength, psi	Final Tensile Strength, psi
Unalloyed	37,500	11,900 to 21,400
0.10 V	41,500	16,200 to 31,100
0.20 Zr	32,500	9,300 to 18,600
0.20 Zr, 0.10 V	34,000	16,400 to 25,500
1.50 Cu, 0.10 V	40,500	27,400 to 34,700
0.20 Ti, 0.10 V	37,500	12,000 to 30,500



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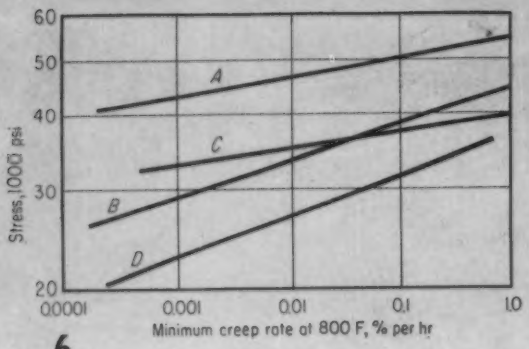

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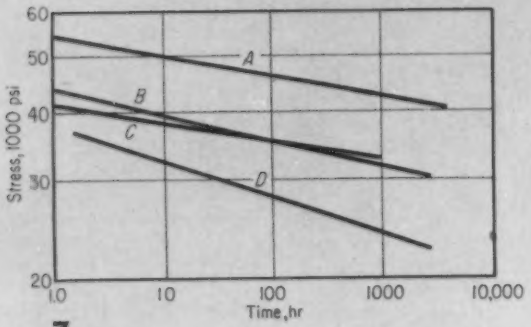

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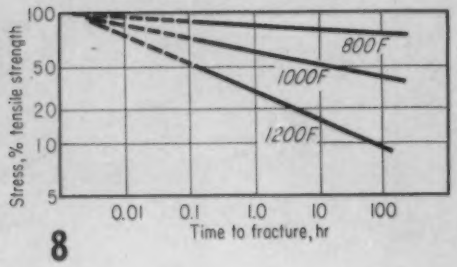

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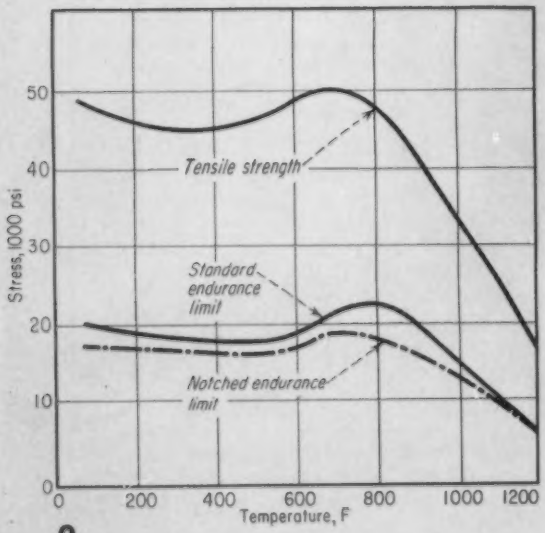
Table II—Short-time Compression Creep for a Class-35 Gray Iron at 1110 F

Stress, psi	Time, hr	Permanent Strain, %
4,260	4	0.11
5,680	4	0.18
7,100	4	0.30
8,520	4	0.50
9,940	2	0.62
11,360	2	0.90



9

5 Creep and growth . . .
of a typical class-40 unalloyed gray iron at 930 F.

6 Minimum creep rates . . .
at 800 F for four gray irons.

7 At 800 F . . .
same four materials have good stress-rupture properties.

8 Stress-rupture life . . .
of a class-40 gray cast iron decreases with rising temperatures

9 Hi-temperature fatigue . . .
properties of a gray cast iron.

TABLE III—Compressive Creep Rates at 750 F for Five Alloy Gray Irons
Creep, in. x 10^6 per in. per hr

Stress, psi	Time, hr	Alloy Additions				
		0.31 Cu	0.51 Mo	1.51 Cu 0.41 Mo	1.36 Cu 0.82 Cr	4.08 Si 1.26 Cr 0.91 Mo
20,000	1,000	20	19	45	31	25
	2,000	10	12	24	12	22
	2,500	7	11	22	9	20
15,000	1,000	17	8	25	20	13
	2,000	9	5.5	19	7.2	10
	2,500	8	5.0	14	4.5	9
10,000	1,000	11	1.5	14	10	4.5
	2,000	4.5	1.3	8	5	2.8
	2,500	4.5	1.3	7	4	2.6
5,000	1,000	5.2	0.2	4	0.8	1.2
	2,000	3.0	0.2	3.5	0.7	1.0
	2,500	3.0	0.2	3.5	0.7	1.0
Tensile Stress		47,000	55,500	64,000	56,000	43,300
Hardness, BHN		235	255	269	285	207

of 150 cycles of rapid heating to 1500 F. This lowered strength resulted from permanent damage to the metallurgical structure.

Modulus of elasticity decreases gradually with elevated temperature until 800 F, Fig. 2. It then becomes more marked and, at 1000 F, is 15% lower than at room temperatures—a percentage comparable with the drop for carbon steel.

Compressive strength, too, decreases with rising temperature, Fig. 3. The strengths in compression are 3 to 5 times the tensile properties at all temperatures and gray irons—throughout their useful range—can usually be used without danger of buckling.

Hardness and wear resistance in a given type of cast iron show a correlation. When hardness goes down with elevated temperature, so does wear resistance, Fig. 4. Sliding wear is low at room temperature, owing to free graphite in the microstructure. Wear increases noticeably above 600 F, the point where the graphite oxidizes, pearlite in the microstructure coarsens, and the compressive strength decreases.

Creep is deformation of metals under long-time tensile loads lower than yield strength. Ordinarily extremely slow, creep only becomes important at elevated temperatures. For cast irons an additional increase in dimension is introduced by the growth under no-load. Total deformation therefore includes that from plastic and elastic mechanical strain, and growth from metallurgical causes. The creep of unalloyed iron with 42,000-psi tensile strength, under various tensile stresses at 930 F, is given in Fig. 5. The curves show a rapid increase in strain with increasing stress, also show the characteristic first-stage creep followed by a slower constant second stage.

Tensile creep for several gray irons, at different stress levels and at 800 F, is given in Fig. 6. Alloying materials, notably molybdenum, supply creep resistance at high temperatures. The lowest creep rates are obtained by alloying with chromium and molybdenum. Another beneficial addition is the chromium-nickel-molybdenum vanadium combination.

Compression creep for some gray irons is tabulated in Tables II and III. They show that creep rate gradually increases with higher stress but decreases with time. Compression creep strengths are much higher than tensile creep—the total deformation can reach relatively high values without failure. Therefore, tensile creep is usually the more critical value.

Stress rupture properties of gray iron are useful when permanent deformation can be ignored and the main objective is to prevent or predict failure by rupture. These properties usually follow a straight line (on log-log plot) unless a change in microstructure occurs. As shown in Figs. 7 and 8, time required for rupture decreases markedly with increasing stress. The same irons at 1000 F gave high creep rates and sharp decrease in stress-rupture properties when tested beyond 50 hr, indicating structural instability at this point.

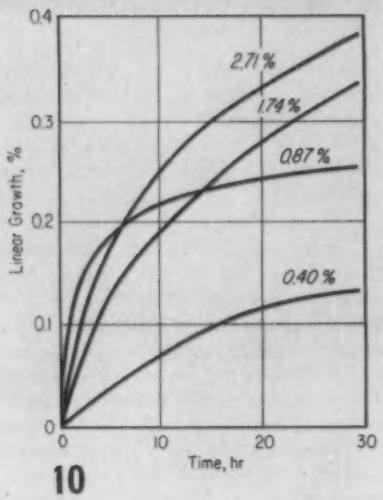
Fatigue properties are only slightly affected up to 800 F. Beyond, the endurance limit decreases rapidly, Fig. 9. Austenitic gray irons, however, can maintain their fatigue strength up to 1160 F, and special low-silicon irons even increase in fatigue strength from room temperature to 400 F.

Notch fatigue properties are also given in Fig. 9 and approximate the standard fatigue values for all temperatures. This similarity shows very low notch sensitivity when subjected to mechanical fatigue.

Thermal fatigue is susceptibility to failure from stresses caused by repeated thermal cycling. In selecting cast irons for thermal-shock applications, avoid irons with high modulus and expansion, and low conductivity. Also design to eliminate sharp temperature gradients and section changes which can further induce cracking. Slower cycling applications allow some of the thermal shock to be absorbed by elastic and plastic flow; thermal fatigue can be improved by small additions of both molybdenum and nickel. The allowable tensile strength at 800 F under thermal fatigue conditions is appreciably lower than the 10-year rupture strength for these irons. Values are listed in Table IV. The successful service of many cast irons in stove and boiler parts, gas and diesel-engine applications, demonstrates their good thermal shock resistance.

Growth is the permanent increase in volume which occurs after prolonged heating above 900 F or repeated thermal cycling from that temperature. Causes of this change are: decomposition of carbides into ferrite and graphite, which have higher specific volume; internal oxidation of the iron; crazing or cracking from thermal stresses. When the last occurs, oxidation rate is considerably increased.

The growth of a completely pearlitic unalloyed gray iron at 930 F is about 1.8 x 10^{-3} in. per in. in air. Influence of the amount of combined carbon on linear growth at 1200 F graphitization, Fig. 10, shows that unalloyed irons with highest combined carbon undergo



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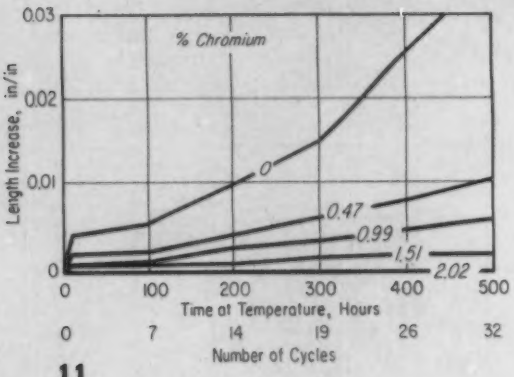

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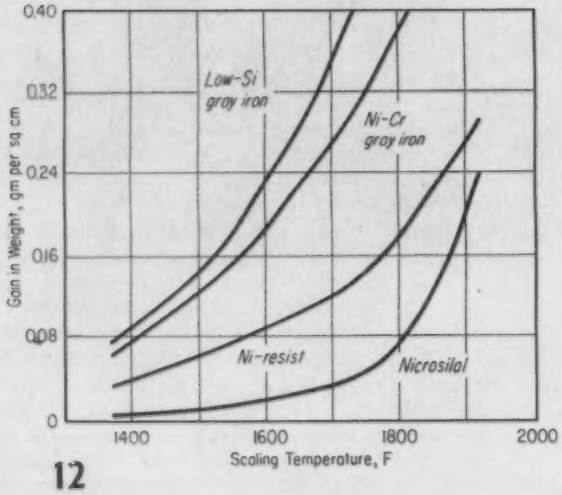

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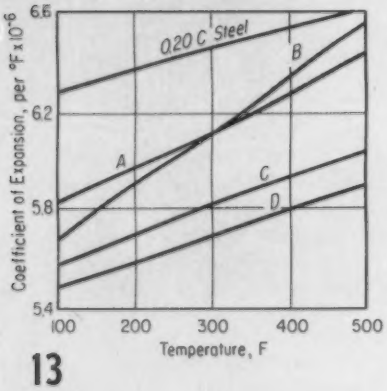

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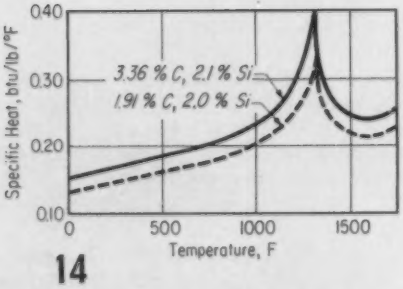


14

10 High combined carbon . . .
increases growth of gray cast iron at 1200 F in vacuum.

11 Chromium content . . .
lowers growth caused by cyclic heating of gray iron to 1472 F.

12 Comparative scaling . . .
of cast irons after 200 hr of heating in air.

13 Coefficients of expansion . . .
of these gray irons are lower than for low-carbon steel.

14 Specific heat . . .
of two gray irons are markedly increased when higher temperature transforms ferrite to austenite.

Table IV—Ten-year Rupture & Thermal-Fatigue Strengths for Gray Irons at 800 F

Alloy Addition	Rupture Strength, psi	Tensile Thermal Fatigue Strength, psi
Cr-Mo	30,000	17,500
Mo	25,000	15,000
Cr-Ni-Mo-Va	25,000	16,000
Unalloyed	15,000	12,500
Ni-Mo	25,000	18,000

Table V—Thermal Conductivity of Medium and High-strength Gray Irons

Type	Chemical Analysis, %								Conductivity btu/hr/sq ft/ °F/in.	
	C	Si	Mn	Ni	Cr	Mo	Cu	W	212 F	752 F
Class 40, low Si	3.35	0.65	0.85						391.9	330.9
Class 40, Cr	3.17	1.40	0.97		0.39				380.3	334.5
Class 40, Ni	3.16	1.56	0.94	0.75					324.5	293.2
Class 40, W	3.02	1.89	0.76					0.48	344.5	304.8
Med. str.	3.20	1.56	0.72						351.3	324.5
Med. str., Cu	3.18	1.58	0.69				1.58		325.1	293.2
Med. str.	3.11	2.26	0.39						222.2	293.2
Med. str., Cr-Mo	3.12	2.31	0.39		0.54	0.77			345.5	316.4
Low carbon	2.61	2.46	0.45						319.3	290.3
Class 50, Ni-Cr	2.80	2.51	0.68	1.71	0.54				293.2	267.1
High Mn-Ni	3.10	2.51	3.11	1.00					307.7	281.6
Low carbon, Mo	2.56	2.20	0.63			0.58			344.5	324.5
Class 45, Ni-Cr	3.41	1.03	0.65	1.49	0.54				236.7	307.7

fastest growth. Silicon and other degraphitizers increase growth rate, and carbide stabilizers—particularly chromium—slow it down effectively, but such alloys are generally not required for strength under 850 F.

Normally, graphitization is not a problem below 750 F although coarse-grained gray irons, in boilers for 20 or 30 years, can graphitize at as low as 600 F. Small amounts of chromium, molybdenum and vanadium will reduce growth at these and higher temperatures. Chromium is superior; its effect is shown in Fig. 11. Copper and nickel promote graphitizing slightly and are sometimes added to maintain machinability—they reduce the tendency of chromium to harden gray cast iron. Oilless bearings with a stable porous structure that is permeable to oil can be made by repeated thermal cycling to induce growth. This gives a structure with good machinability and a tensile strength of 23,000 to 27,000 psi.

Internal oxidation occurs in gray iron; but only above 1200 F does it increase growth. Rate of internal oxidation depends on the atmosphere and is higher under highly oxidizing conditions. Here too, chromium is the best antidote. Additions of titanium reduce oxidation, but not as much as chromium. High additions of silicon, nickel and aluminum are also effective.

Scaling in air forms a mixture of iron oxides. Rate of formation is determined by whether the scale is adherent and protective, or cracking and flaking. An adherent scale is protective and gradually reduces further scaling while loose scale will flake off and expose the fresh surface to further scaling. The effect of temperature and alloy content on scaling is shown in Fig. 12. High additions of chromium, silicon or aluminum reduce scaling the same way they reduce internal oxidation, but vanadium is only slightly effective. Sulphurous atmospheres also oxidize gray iron; high nickel is not helpful here. Conditions vary so widely that each case should be considered separately to select a suitable alloy gray iron.

II—PHYSICAL PROPERTIES

Thermal conductivity of plain gray iron at room temperature ranges from 222 to 392 btu/hr/sq ft/ °F/in., depending on structure and composition. As content of graphite increases and its flakes become coarser, conductivity goes down. Conductivity is higher in ferritic than pearlitic irons and definitely lower in white irons. Higher temperature decreases the conductivity for plain and alloy irons. Several types of cast irons at different temperatures are listed in Table V.

Thermal expansion is approximately 6 x 10^{-6} in. per in. per °F, slightly lower than with steel. The value, however, depends on microstructure, temperature and composition. The expansion coefficient increases with temperature; Fig. 13 compares the changes with those of mild steel. Austenitic gray iron has a higher coefficient, about 11 x 10^{-6} in. per in. per °F, and is often used with aluminum and its alloys for compatibility. Chromium raises the expansion somewhat but much nickel can reduce it to very low values.

Specific heat of gray iron is about 0.13 btu/lb/°F at room temperature. The value is an average of values for each constituent, so will vary with structure. Annealing, for example, gives a slight reduction because the specific heat of graphite is lower than that of iron carbide. The value generally increases with temperature as shown in Fig. 14. The peak at about 1380 F is caused by the ferrite-to-austenite transformation.

Corrosion by Molten Metals

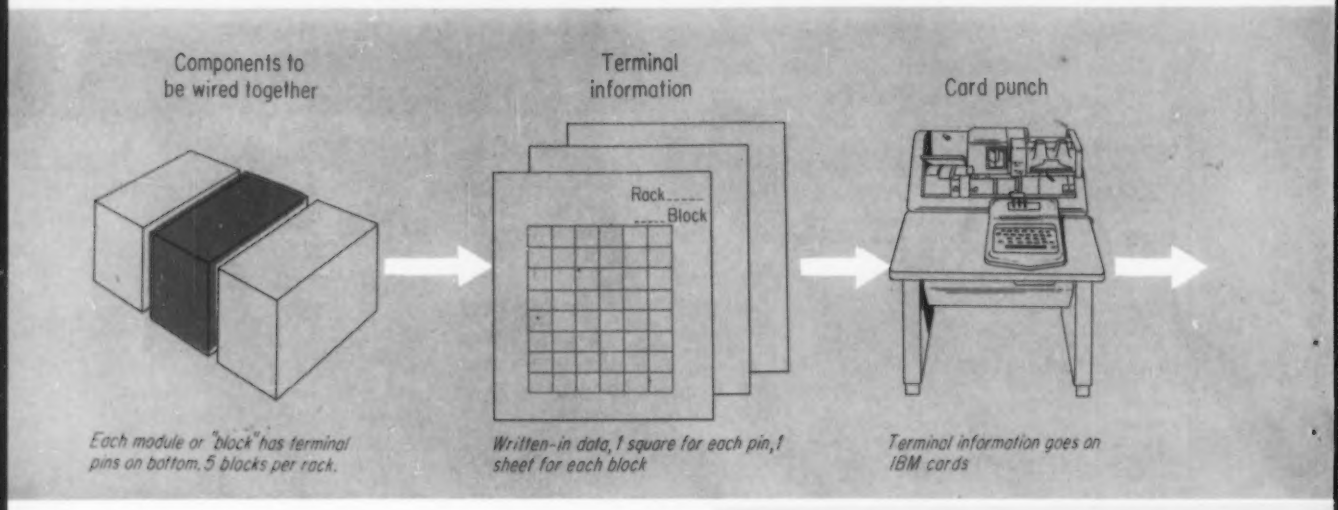
Gray cast iron is frequently used for melting and handling molten lead, zinc, magnesium and aluminum. Three reactions here govern the rate of corrosion of the iron: its going into solution; its deterioration by thermal fatigue, growth or rupture; attack by oxygen or sulphur in the molten metal dross or combustion zone of burning fuel. In all these, increasing temperatures increase rate of attack. Usually, cast irons can handle molten metals only where solution rates are low; or where corrosion resistance can be improved by preoxidation at about 1550 F in air, or by aluminizing the surface to make the application economical.

EDITOR'S NOTE: Recent articles on various problems and applications concerning cast irons:

"Ductile Iron Halves Cost," Aug '57, p 162 describes a typical redesign to reduce cost with no loss of strength.

"Wear Properties of Ductile Cast Iron," Feb '53, p 125 shows the wear resistance of ductile or nodular cast iron is the same as that of gray cast iron in spite of differences in structure.

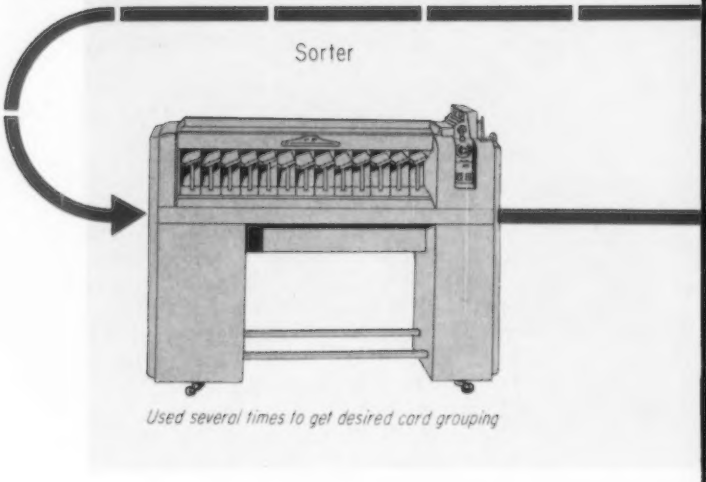
"High-temperature Test Data and Their Importance in Design," Oct '53, p 182 shows how to design from elevated-temperature properties.


Components to be wired together
Terminal information
Card punch
Rack
Block
Each module or "block" has terminal pins on bottom. 5 blocks per rack.
Written-in data, 1 square for each pin, 1 sheet for each block
Terminal information goes on IBM cards

punched cards . . .

ANSWER TO WIRING WOE

DICK W. MELVILLE
Head, Computer Department
Stanford Research Institute, Menlo, Calif.



Electrical equipment is labor-saving but, before it can do its job, considerable wiring may be necessary. This is where another labor-saver can go to work. Card-punch equipment will cut down the size of even the biggest jobs of designing control circuits. Miles of wiring, which would otherwise require mountainous piles of blueprints and instructions, now become easily handled molehills—with neat stacks of cards describing each connection in a coded language of their own.

These cards can be used throughout the wiring project. For example, they can be fed into tabulators that automatically figure the most economical wiring arrangement. And as a final step, they can be sorted out into a handful of cards telling the wireman just where to make any particular batch of connections. He can even have cards of different colors defining categories of information, such as blue for signal sources and white for loads.

Manual methods are tedious on complex circuits, not only because each terminal connection requires careful planning and drawing, but also because of the extensive replanning and redrawing that results from new information and corrections. By contrast, punched-card systems do it all—avoid inefficient connections, correct errors quickly, produce highly accurate data which is completely dependable. Here's a case history:

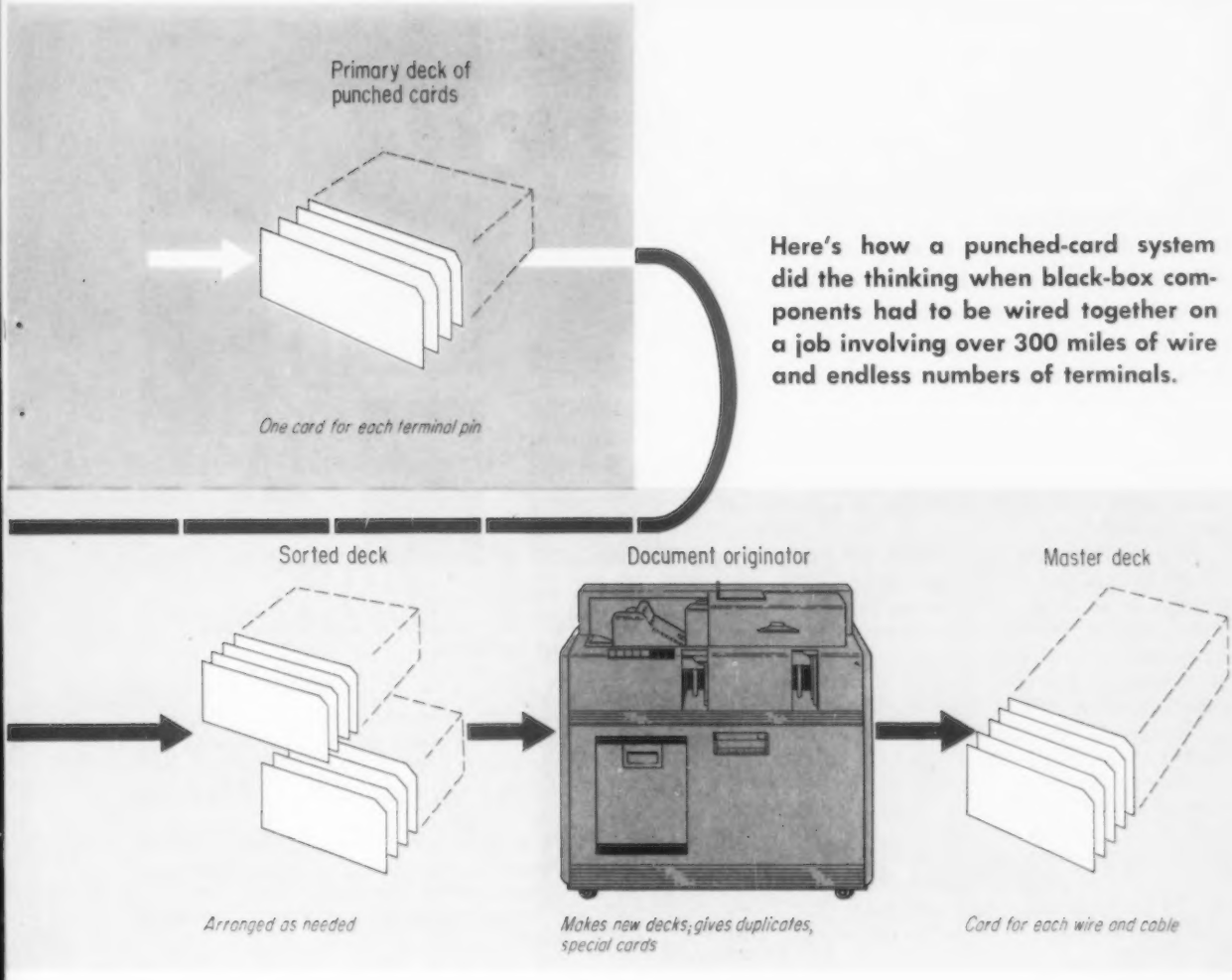
1,600,000 Feet of Wiring

A large-scale digital computer called ERMA (Electronic Recording Machine Accounting) was being built for the Bank of America by Stanford Research Institute. ERMA would occupy approximately 2,500 sq ft of floor space, contain 1,600,000 ft of wire, 8,000 vacuum tubes, and 34,000 diodes. The problem was how to keep track of all that wiring.

Wiring specifications, derived from "logic diagrams" (functional circuit drawings), described racks of equipment that had to be tied together. This posed a difficut problem—it was impossible to specify interconnections until all the racks had been designed. After that a staggering job of collating would be necessary: to find the common connections located at random in the system and tie them together most efficiently.

However, a small (8%) segment of the inter-rack wiring seemed clear-cut enough for a tryout of the old manual method. This was made.

It began with large sheets of paper (22 x 36 in.) ruled into 1½ by 2-in. rectangles, each representing a unique


Primary deck of punched cards
One card for each terminal pin
Sorted deck
Document originator
Master deck
Arranged as needed
Makes new decks; gives duplicates, special cards
Card for each wire and cable

Here's how a punched-card system did the thinking when black-box components had to be wired together on a job involving over 300 miles of wire and endless numbers of terminals.

pin connection in a bottom terminal block. There were five blocks per rack, so five sheets were needed to describe the inter-connections of one rack. Each rectangle then indicated an address to which a wire was to be connected (using a double-addressed scheme), name of the carried signal, sensitivity of the wire with respect to other wires, and location of power section supplying the signal source. There was barely enough space to record all the information.

The amount of paper (150 sheets) for just one segment of wiring was excessive and when groups of technicians, each armed with 30 sq ft of paper per rack, began wiring, the situation became worse. Meanwhile, changes in wiring had to be shown on the sheets and clerical errors had to be corrected. With so much handling the sheets were now dog-eared and illegible. A better method was needed.

It was determined that in any manual system a large force of clerks (15 to 20 people) would be necessary. This led to the decision to mechanize instead—with a punched-card system for speed, accuracy and economy.

Such a system would have to tabulate each signal source and its loads separate from other signal sources and loads, and tie each together in proper wiring sequence; store wiring data, cable by cable and rack by rack, for the wiring work; and also supply records in various formats for maintenance purposes.

Do It With Cards

The first data-handling step was to transfer information from the inter-rack wiring sheets to punched cards —one card for each square representing a terminal. All signal sources were punched on blue cards, all loads on white cards with right-hand corner cuts, and unused terminals on white cards with left-hand corner cuts. The code used, of course, had to be consistent.

The end result was a large file of cards which were sorted into alphabetic order by "logic" source descriptions to produce unique groups of sources, each with their respective loads. Another sorting placed each group in proper wiring sequence. Then, the entire file was run through an IBM-519 document-originating machine. It turned out double-addressed cards (the Master Deck), each representing a unique wire in the system. From these, other cards were produced for different presentations of the information.

The Master Deck was then reproduced by the document-originating machine in two ways; direct duplica-

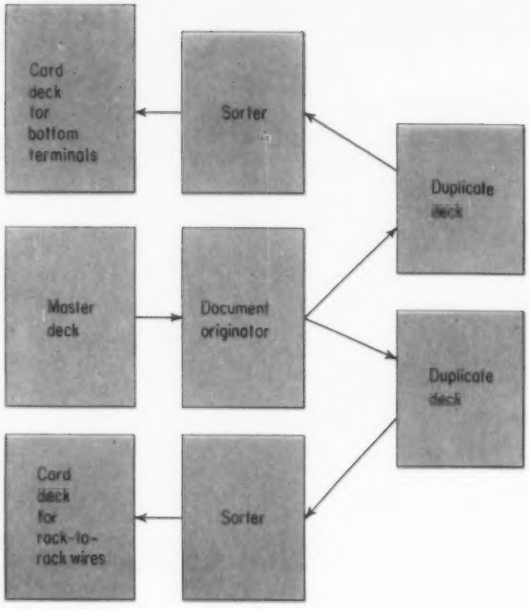
tion on green cards, reversed fields on red cards. These two decks were mixed together with blank (unused) terminal cards originally made in the transfer operation. The resulting, combined deck was sorted according to sequence of pins in bottom terminal blocks of each rack, and was called the bottom terminal deck.

The master deck was reproduced twice more, direct and reverse field, on yellow cards. These were sorted by category (signal, load, etc.) and by rack-to-rack wiring information. Result was groups of cards that represented cables connected from a lower-numbered rack to a higher-numbered rack.

An up-to-date report of information could be had fast by duplicating a set of cards or making a file tabulation. For changes, the master list was consulted to identify the master card or cards to be changed; the computer operator, in turn, found, corrected, and refiled the master card and all other cards made from that master. Periodically, new tabulations were made to replace worn old ones.

All information, therefore, was exactly duplicated in all places, and any change was automatically carried through to all areas. Once discovered and corrected, errors never reappeared in the system. The computer equipment was rented, and it proved more economical than hiring an equivalent number of clerks. Required were: key punch, verifier, sorter and document-originating machines. Tabulator work was contracted with a nearby computer service bureau, and the amount of required operating time was relatively small.

A big advantage was having all the needed information stored conveniently for easy extraction of reports. For example, when a request was made for a listing of all neon indicators in the system, the Master Deck was reproduced, and all neon cards quickly sorted out and tabulated without disturbing the order of the files. Wiremen who requested special wiring sequences got tabulated working sheets easily but usually he preferred to wire directly from cards and use the tabulated lists for checking purposes.



Master deck . . .
is neatly duplicated and sorted to produce almost any combination of information.

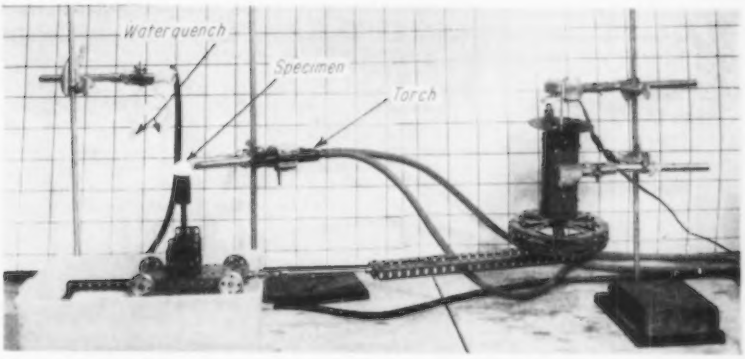
EDITOR'S NOTE: Other phases of punched-card technology have been covered in: "Polynomial Cam Curves," Mar '57, p 196; "Punched-Card Fed High-Speed Printer," June '55, p 144; and "Using Punched-card Equipment for Automatic Machine Tool Control," June '55, p 172.

HYPOTHETICAL TABULATION

SOURCE DESCRIPTION									RACK-TO-RACK WIRING														
TIMING	PRIME	LOGIC SOURCE					CATEGORY	SOURCE	CONNECTOR	FIRST UPSTAIRS RACK ADDRESS			BOTTOM OR SIDE TERMINAL				BOTTOM OR SIDE TERMINAL				FIRST UPSTAIRS RACK ADDRESS			REVERSE CARD	CABLE NO
		PKG TYPE	LOGIC SER NO	SEC	PWR	PIN NO				PREFIX	LOCATOR	PIN NO	RACK	LOCATOR	PIN NO	PIN NO	RACK	LOCATOR	PIN NO	PIN NO	PREFIX	LOCATOR	PIN NO		
		FF	251	B		29	B2Y	02	AA		D07	11	02	VA	01	02	06	WH	11	12		F01	09		
									AB		F01	09	06	WH	11	12	10	YA	03	04		A01	33		
									AC		A01	33	10	YA	03	04	16	XF	09	10		G04	27		
									AD		G04	27	16	XF	09	10	26	ZA	17	18		E04	15		
									SA		D07	11	02	VA	01	02	07	UB	04	05		B04	21		
									SB		B04	21	07	UB	04	05	13	XH	11	12		C07	11		
		FF	255	B		29	A2	08	AA		F11	29	08	ZB	01	02	12	YA	11	12		B09	27		
									AB		B09	27	12	YA	11	12	26	WG	13	14		C07	33		
									SA		F11	29	08	ZB	01	02	05	VH	04	05		E01	09		
									SB		E01	09	05	VH	04	05	09	XB	13	14		F11	07		
									SC		F11	07	09	XB	13	14	17	ZC	01	02		A07	27		
		LA	15	A		35	B3Y	16	AA		A04	27	16	YF	15	16	14	ZC	11	12		E04	15		
									AB		E04	15	14	ZC	11	12	12	VE	09	10		C08	31		
									AC		C08	31	12	VE	09	10	08	ZA	01	02		B12	12		
									AD		B12	12	08	ZA	01	02	02	VC	19	20		G12	11		

Wireman's working sheet . . . is output of tabulator method; input is group of punched cards.

WHICH COATING AT HIGH TEMPERATURE?

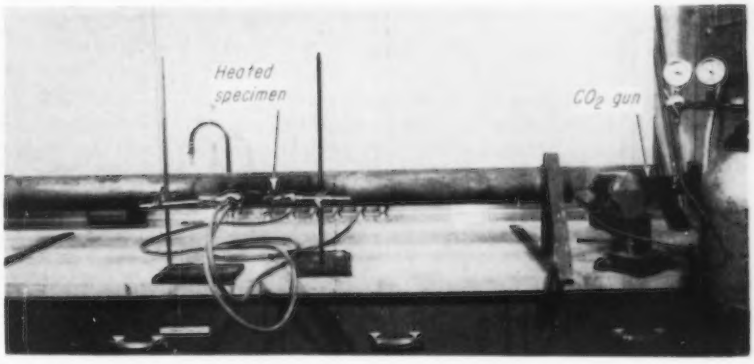


Hot, then cold . . .
a tough test for metal coating, is made with this apparatus built from toy construction set. Specimen oscillates between 2000-F gas torch and running water to simulate thermal shock in jet engine.

High temperatures make extra demands upon most materials, and protective coatings are no exception. What types are best for corrosion resistance, erosion resistance, compatibility with base metal? Here are guideposts.

GORDON D. OXX, JR.

Metallurgy and Ceramics Dept.
General Electric Research Laboratory



Sophisticated zip-gun . . .
tests coating for resistance to low-velocity impact. Steel-tipped lead slug is fired by CO_2 from gun (right) through tube to heated specimen (left). Projectile energy required for failure at constant coating thickness correlates with coating hardness.

Above 1000 F, environment starts doing its worst damage to metals. It is also where coatings become important life-savers; they ward off the attacks of both corrosion and erosion. Coatings cannot yet be designed with complete precision. But here are guides which, added to environmental tests, promise a fine chance of success. The coating should:

- **Control oxidation of the base metal**
- **Prevent erosion**
- **Be compatible with the base metal**

SURFACE OXIDATION

Good resistance to oxidation above 1000 F is found in two types of coating materials: (1) metals and alloys that form adherent oxide scales, (2) materials that are inert to high-temperature oxidizing atmospheres.

Protective scale formation on many coating metals is promoted by chromium additions of about 20%. Typical iron-base coating alloys are those austenitic (AISI 300 series) and ferritic (AISI 400 series) stainless steels which have additions of 20% or more. Cobalt-base super-alloys designed for the same needs contain 15% to 20% chromium. Nichrome, a nickel alloy with 20% Cr, is another example.

A simple binary iron-aluminum alloy, "Alfenol," (16% aluminum) has good oxidation resistance at high temperatures. Better Ni-Cr alloys with aluminum additions are available now. Many iron-, nickel-, and cobalt-base alloys have chromium or chromium-aluminum additions for good oxidation resistance. Some contain other elements to improve strength. These elements can

TYPICAL COATING COMPOSITES

Basis Metal	Coating	Applied by	Advantages	Limitations	Temp. Limit, F
Molybdenum	Nickel	Roll cladding Electrodeposition	Easily applied, formable after application, ductile, free from flaws, impermeable to oxygen	Thermal expansion mismatch, forms brittle NiMo interface after heating, not useful in sulphur-bearing atmospheres, poor erosion resistance	1800
Molybdenum	Low-melting nickel base alloys with silicon and boron	Flame-spraying	Resistant to low-velocity erosion, inexpensive to apply, free from flaws, impermeable to oxygen	Same as nickel, brittle at low temperatures, can not be post-formed	2000
18-8 Stainless, or similar alloys	Chromium	Diffusion Electrodeposition	Composite cheaper than high alloy irons; high hardness, low oxidation rate below 2000 F	Cannot be postformed, subject to flaws when electrodeposited, corrodes by nitride formation above 2000 F, forms brittle CrFe interface after heating	2000
Alloys of iron, nickel, molybdenum, cobalt, etc.	Alumina	Flame-spraying	Inert, high hardness, low expansion coefficient puts coating in compression (except on Mo), can be applied to many materials	Brittle, cannot be postformed, tends to be permeable to oxygen, inertness sometimes prevents good bond	2000 and above

adversely affect oxidation resistance, so a complex high-temperature alloy should be chosen with care.

Oxygen may not be the only corrosive troublemaker. Sulphur, carbon, or even nitrogen in an operating atmosphere can attack some of the oxidation-resistant coatings—for example, nickel or nickel alloys in presence of sulphur.

Inert coating materials tend to be more corrosion resistant than the protective-scale type, but are limited to ceramics, either glassy enamels or crystalline ceramics, and some costly noble metals such as gold and platinum. Ceramics may also be unsatisfactory because of brittleness under high stress or impact loading. A crack can cause failure of the basis material by oxidation through the opening, and may grow into the basis metal and cause brittle fracture or a fatigue failure. If cost is not important, or if low notched-impact or fatigue strengths can be tolerated, a ceramic or a noble metal may be desired.

Permeation of a corroding gas through the coating is another important limitation. There are several steps that control the rate:

- **Solution of the gas atoms in the coating surface**
- **Diffusion of gas atoms through the coating**
- **Transfer of gas atoms across the interface between coating and basis metal**
- **Chemical reaction of the gas atoms with the basis metal**

The over-all rate of permeation will be controlled by surface characteristics of the coating material and its interaction with the environment. One control is to form a protective oxide scale on the coating which often reduces the number of gas atoms available for solution. But it may still be necessary to attack the other causes of gas permeation.

Diffusion coefficients of gases at elevated temperatures are generally high—and beyond the designer's control. But it is possible to reduce the over-all passage of gas if it has low solubility in the coating metal; rate of permeation will then also be low, and so will chemical-reaction rate of the gas with basis metal.

If the other methods will not prevent gas permeation, a last resort is to introduce an impermeable material, such as chromium, at the interface. However, this material must be compatible with both basis metal and coating, and form a strong bond between the two.

For low permeation the best coating is one in which the corroding gas is essentially insoluble, and which forms a protective scale by reaction with the gas. If these aren't possible, an intermediate layer should be used.

EROSION RESISTANCE

When softened by heat, a surface becomes more vulnerable to mechanical wear or abrasion. The erosion resistance of high-temperature coatings is not as well understood as oxidation resistance. Erosion comes when small, relatively high-velocity particles (either solid or liquid) strike the material. They indent the surface or fracture off a piece. Degree and type of erosion vary considerably with particle characteristics, speed and eroded material.

At low particle velocities, a high surface hardness is desirable. This can be obtained several ways. If metal cladding is economical, it can be an alloy with high hardness at the service temperature. It may also be

possible to treat the coating material—chromizing it, for example—to make its surface a stronger alloy. An alternative would be a ceramic or glass coating—glass enamels are available with good erosion characteristics at high temperatures.

With high-velocity particles, high hardness is not necessarily desirable. A soft material deforms plastically at the point of impact and absorbs the energy without destruction of the coating. A hard material is more likely to fracture under high loads and render the coating useless as a barrier.

It is necessary to test selected coating materials under simulated service conditions to indicate whether a hard or soft material should be chosen. Two typical tests are shown in photos on page 61. Neither the thermal cycling test nor the impact test will tell precisely how a given coating will behave in service. But the influence of the various parameters can be studied and coating systems compared. With these two tests, successful coatings for jet engine blades have been designed.

COMPATIBILITY

Properties of the coating and basis metal may undergo change because of the union itself.

Chemical incompatibility arises from diffusion of coating and basis metal into each other—often after prolonged exposure to high temperature. The diffusion may have undesirable consequences predictable from the phase diagram of the two components. If this diagram shows a composition with melting point below the service temperature, the coating will be unsatisfactory—eventually a liquid will form at the boundary, weakening the bond.

The converse can happen too. A coating, liquid at service temperatures, may solidify because of composition changes that occur on diffusion. Aluminum or high-boron alloys have been successful in coatings because of increase in melting point that results from diffusion. The phase diagram may also indicate existence of an intermetallic compound. Such phases are usually brittle, and if present at the interface, may cause failure. An example is nickel on molybdenum, where the compound NiMo gives a brittle phase undesirable in some cases.

Best answer to chemical incompatibility is an intermediate layer that forms an acceptable interface with both the outer coating and basis metal. Nickel as a barrier between steel and chromium might prevent formation of brittle chromium-iron alloys; diffusion of nickel into the steel would likely improve mechanical properties. A similar example is an interleaving of thin vanadium sheet between titanium cladding on steel.

Mechanical incompatibility occurs when tensile stresses induced by differing thermal expansion of basis metal and coating exceed the yield point of either component. The result can be coating rupture, distortion of the composite, or failure of the bond.

Stresses caused by mismatched expansion coefficients can be remarkably large. For example, the coefficients of nickel and iron differ by only 15%, but tensile stresses built up in a thin nickel coating on a steel sheet cooling from 1650 F reach about 40,000 psi. Plastic deformation of the nickel coating results. With repeated thermal cycling this would give early fatigue failure. A nickel-iron alloy coating with a coefficient close to that of iron would lower the stress while only slightly reducing corrosion resistance.

Elastic modulus values of the coating and basis metal also influence induced thermal stresses: the lower the moduli, the lower the stress. But matching thermal coefficients is the most important consideration (see equations on this page). As the difference in coefficients becomes small, relatively rigid materials can be combined under extreme thermal cycling conditions. The value of close matching is so great that other properties are usually sacrificed to attain it. This is particularly true when a large number of thermal cycles are expected during service.

ESTIMATING A COATING STRESS

A simple application is flat plate coated on both sides. The tensile stress induced in coating by thermal change can be estimated from the equations:

$$\Delta T(\alpha_b - \alpha_c) = S_c/E_c - S_b/E_b$$

and

$$2S_c t_c = -S_b t_b$$

where

S_c, S_b = Coating and basis metal stresses, respectively
E_c, E_b = Elastic moduli of coating and base metal
α_c, α_b = Thermal expansion coefficients
t_c, t_b = Thickness
ΔT = Temperature change

Combining these two equations gives the coating stress

$$S_c = \frac{E_b E_c}{E_b + 2E_c \frac{t_c}{t_b}} \Delta T(\alpha_b - \alpha_c)$$

EDITOR'S NOTE: For reports on other recent research on high-temperature materials:

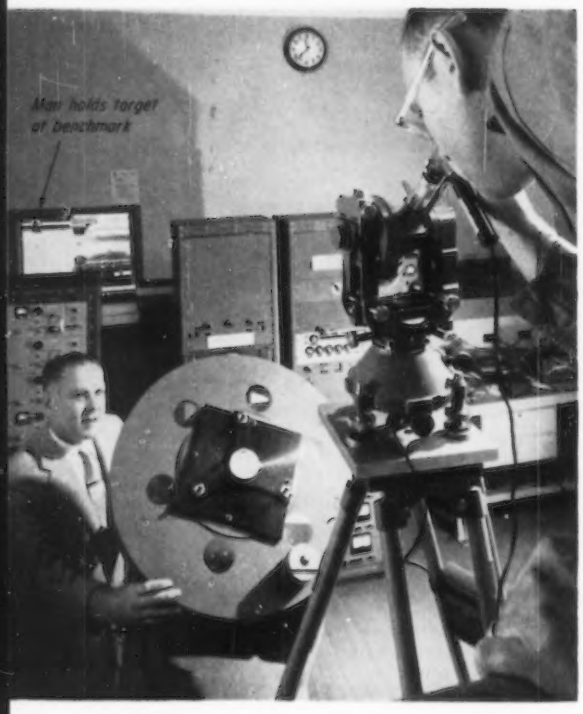
Stanford Research Institute makes progress on a high-vacuum brazing for coating molybdenum with stainless, high-nickel and cobalt allows, Dec 30 '57, p 6. Just announced, Jan 13, p 21, is an extension of standard chromizing technique to molybdenum. Chromalloy Corp. reports successful protection to 2300 F.

Fundamental studies show that ductile ceramics may be feasible, Dec 9 '57, p 9. A low-thermal-expansion ceramic to resist thermal shock is reported, Sept 30 '57, p 70. Flame-sprayed boron nitride coatings extend superalloys to 2200-2500 F—Sept 16 '57, p 118.

On the negative side, "Russians Ahead in Missile Metallurgy," Nov 11 '57, p 115, shows there are still gaps in US high-temperature metallurgy that must be closed if we are to match the USSR.

"Nickel Alloys for Controlled Thermal Expansion," Oct 8 '57, p 65, gives detailed design data on a wide range of alloys. See, also, "Thermal Expansion Coefficients for 51 Metals," Mar '56, p 215.

Applications for a chromium diffusion process are discussed in "Chromizing for Resistance to Corrosion and Wear," Nov '56, p 180.



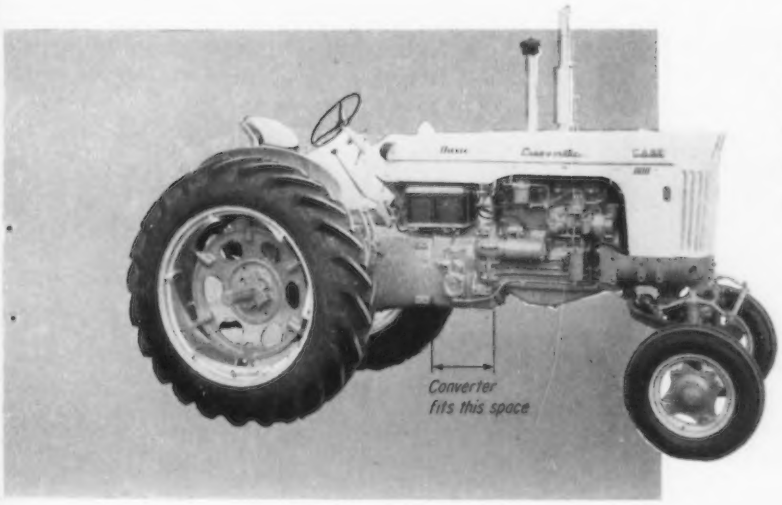
With axis of test table positioned precisely parallel to earth's axis, a single-axis gyro keeps its spin axis fixed in inertial space by rotating the servoed table as the earth revolves. How closely gyro's precession matches earth's rotation measures its accuracy.

The table—shown also on the front cover of this issue—used at Ford Instrument Co., Long Island City, NY., is a modified version of a table first developed at MIT. Gyros rotate on air bearings (Nov 25, p. 99) and are used for guidance systems of *Redstone* and *Jupiter* missiles. Drift rates must be held to less than 1/50° per hr to meet accuracy requirements.

Gyro Test Table "Stops" Earth in Inertial Space

North-south reference line . . .
is established with aid of bench marks located by US Coast and Geodetic Survey team to an accuracy of $\frac{1}{10}$ sec of arc. A window in the lab provides line-of-sight to one bench mark from a theodolite near the test table. With position on earth's surface and deviation of gravity vector from the true vertical known, the theodolite is dipped until line of sight is parallel to earth's axis. Then, theodolite is converted into an autocolimator and a plane mirror is placed on the table, which is adjusted to make reflected crosshair image line up with crosshairs in theodolite. Theoretically, alignment within 3 sec of arc is possible.

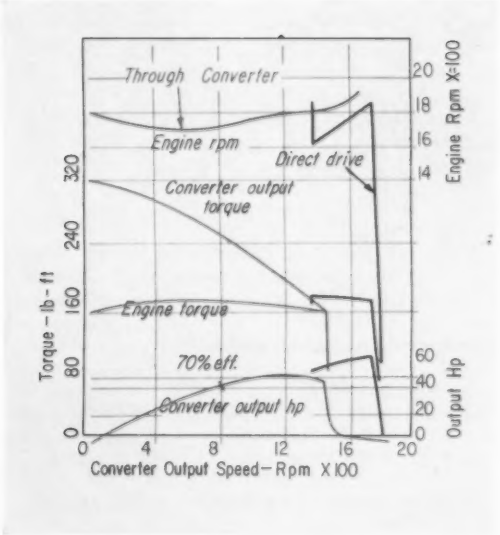
A perfect gyro mounted on table will precess only because rotating earth imposes a torque on its input axis and should rotate table 15° per hr. It is the deviation from this rate that Walter R. Oppen, project supervisor, and his staff want to measure. Relative humidity is held at 50% and temperature kept constant within $\frac{1}{4}$° during tests so precession errors are caused only by gyro's drift. Graduations on glass ring under table trigger a photoelectric counting circuit that actuates drift recorders. Monitors permit 24-hour tests without supervision.



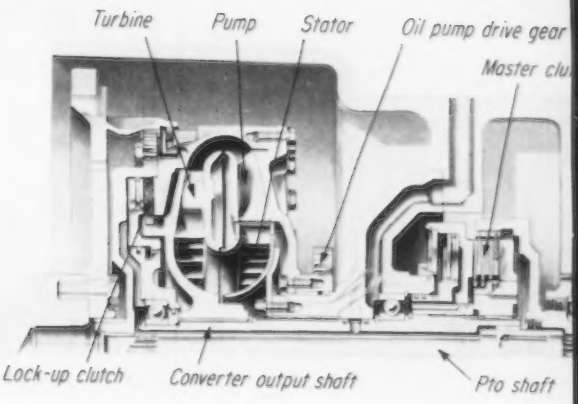
Compact hydraulic clutch locks converter pump and turbine for normal pulling loads; lever on steering column disengages clutch and lets converter multiply engine torque for extra pulling power.

Called Case-o-matic drive, the system was developed under direction of Richard W. Chamberlain, division engineer of J. I. Case Co., Racine, Wis. Converter had to fit between engine and eight-speed transmission of existing tractor. Operator has choice of economical direct drive or variable speed high-torque drive.

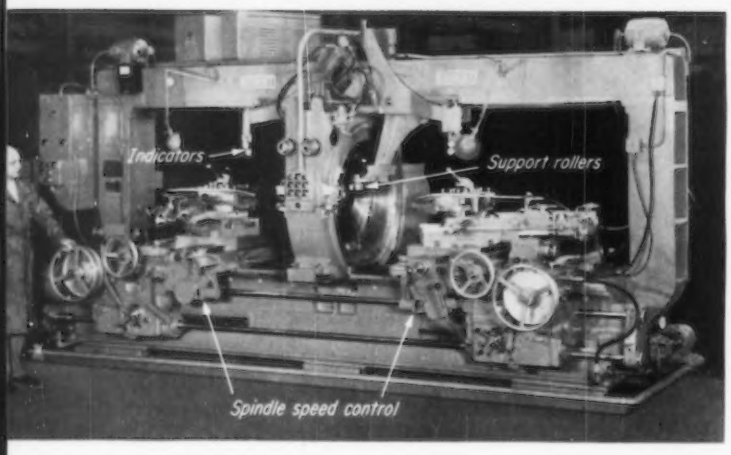
Torque Converter Gives Tractor Two Drives in One



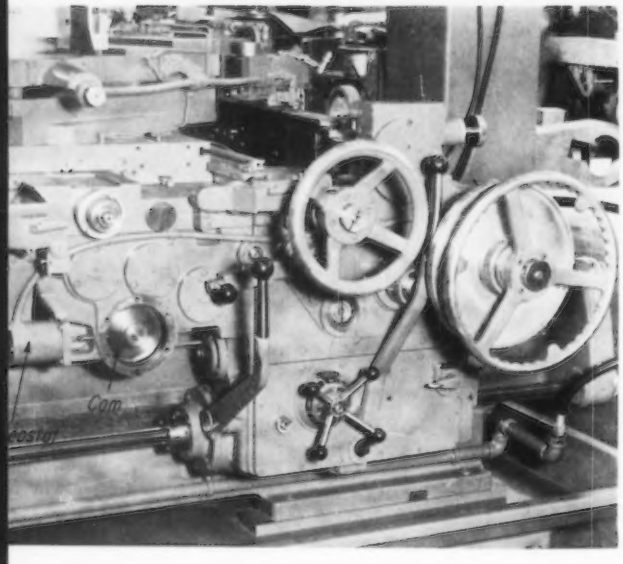
Converter's characteristics . . .
cause it to unload and idle at high speeds when approaching a 1:1 torque ratio. This reduces driving power to that absorbed by oil passing over the fixed stator blades. Pump and turbine are locked for direct drive before this condition occurs and engine characteristics dominate at speeds above the changeover point.



Single-stage converter . . .
was designed to fit space previously occupied by dry-plate spring-loaded clutch and pulley for belt-driven, side power take-off. A live pto shaft, splined into the engine flywheel, also ran through this space and a hollow transmission shaft to a separate clutch at rear of tractor. Converter had to fit available space, include lockup clutch for direct drive, master clutch for disengaging transmission and a stub shaft for the independent pto. Hydraulically actuated wet-disk clutches were principal factors in meeting space limitations. Converter-and-clutch assembly was developed in cooperation with the Twin-Disc Clutch Co. The hydraulic pump, geared to the converter pump, delivers 40-psi oil to the converter and the low-pressure side of each clutch piston. The same pump delivers 140-psi oil to the high-pressure side of the clutch pistons. Converter's hydraulic circuit does not require the stator to freewheel at high speeds.

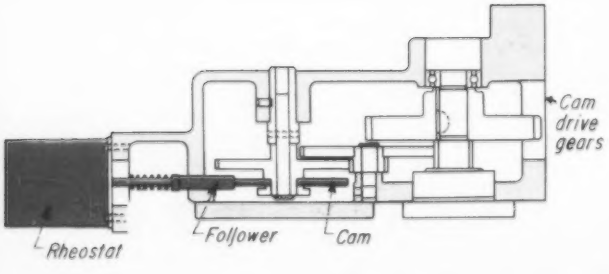


Cam Varies Spindle Speed



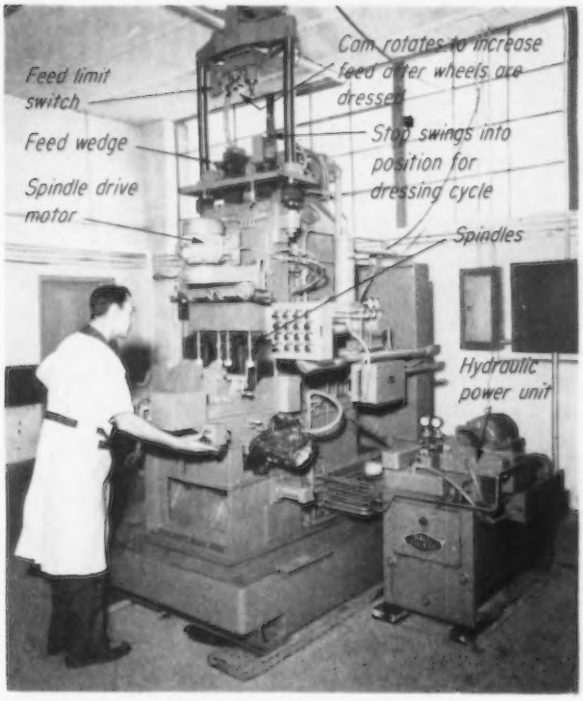
Moving cross-slides in this center-drive lathe rotate cams that vary spindle speed by positioning sliders in control rheostats. Result is constant surface speed under the tool as it moves across the work.

Spindle rotation is reversible to let tool cut on either side of spindle axis. Made by Gisholt Machine Co., Madison, Wis., the lathe was developed to machine simultaneously both sides of thin-webbed turbine and compressor disks. Machining time is cut from 281 to 181 min.



Designed to avoid distortion . . . caused by machining web one side at a time, the center-drive lathe handles disks up to 28-in. dia and has held tolerances within 0.001 in. while experimentally machining webs 0.007 in. thick. Present production disks have 0.080 to 0.115-in.-thick webs. Center-drive unit is reinforced by bridge that carries two movable arms with support rollers. Rollers ride each side of disk hub to prevent distortion during facing cuts. Bridge also carries swinging arms with indicators used to position tools. Each carriage has 24-in. traverse and 34-in. cross travel, and is equipped with multiple-templet tracer slide and four-position toolpost. A 60-hp, variable-speed motor drives spindle in either direction. Cams in carriage aprons rotate with cross-motion and vary spindle speed with tool position. A cut started at one edge of disk can be carried to opposite side, with spindle reversing as tool passes its center.

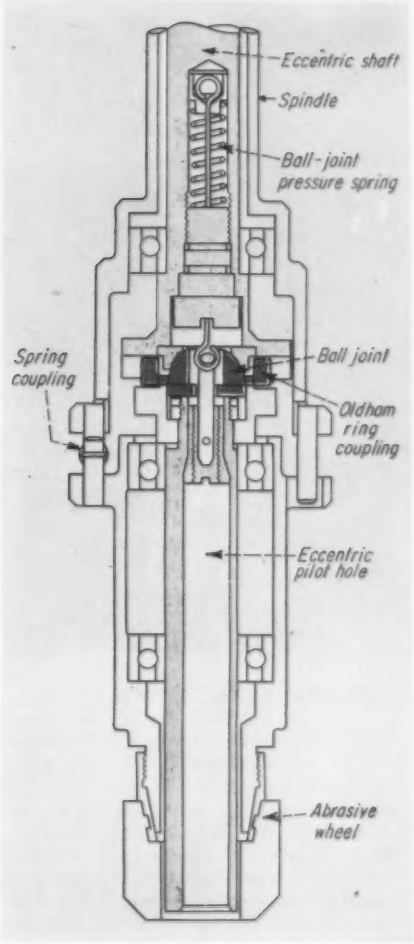
Grinder Cycles Automatically


Feed limit switch
Feed wedge
Spindle drive motor
Cam rotates to increase feed after wheels are dressed
Stop swings into position for dressing cycle
Spindles
Hydraulic power unit

Multiple-spindle valve-seat grinder has two-speed hydraulic feed with automatic dressing adjustment at preset intervals in the production cycle.

Designed for automotive-engine production by Hall-Toledo, Inc., Toledo, Ohio, this machine has spindles which move eccentrically while grinding and float on guide pins to accommodate valve-guide misalignment. Production rate is 400 cylinder heads per hour.

Feed is controlled . . .
by hydraulic cylinder that slides a wedge through a yoke to lower spindles over guide dowels, which locate them in correct grinding position. Wedge has two sections, one for rapid advance and the other for grinding feed. Cylinder speed is controlled by a flow-regulating valve on the hydraulic power unit. Spindles dwell to spark-out at end of feed cycle, then return to idling position. After a pre-set number of cycles, an electric counter positions spindle head against a dressing stop that allows for 0.003-in. abrasive removal. Dresser unit is positioned under spindles hydraulically. Operator then manually disengages the eccentric spindle-axis drives, causing spindles to rotate about fixed centers, and cranks the tools forward to dress all wheels simultaneously. Dresser unit and spindle head then return to idle positions. Pushbuttons start all automatic cycles.

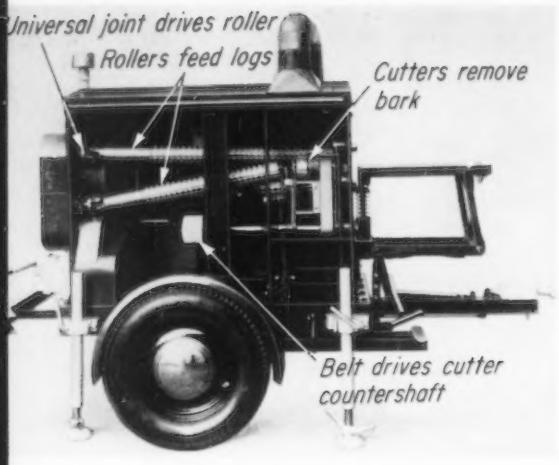


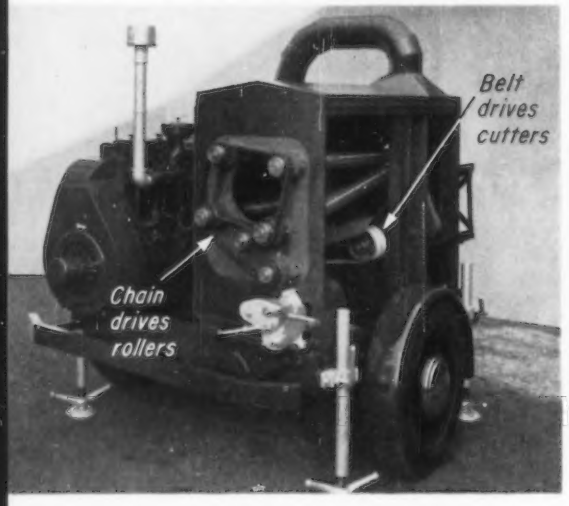
Eccentric motion is generated . . . ▶
by rotating a shaft inside each hollow grinding spindle. Shafts turn at 30 rpm and carry spindles on their lower sections, which are $\frac{5}{8}$ in. off center. Equally eccentric pilot holes in each shaft locate the spindles in correct position over valve seats. Grinding spindles are driven at 10,000 rpm through gears on swinging links that accommodate the eccentric motion. Inner shafts are driven through double-worm-gear speed reductions. A half-ball joint and Oldham coupling combination let bottom sections of shafts and spindles have angular and lateral freedom to accommodate valve-guide misalignment. Power is transmitted through spring couplings.

Skew Rollers Feed Debarker

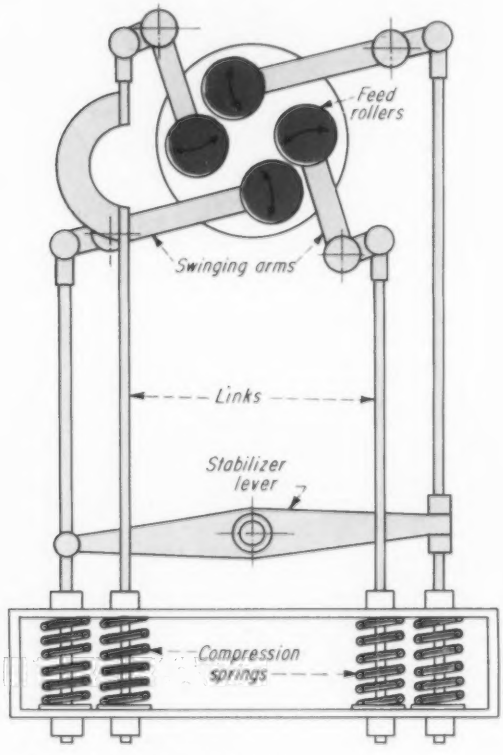
Logs are rotated and pulled axially through a debarking machine by four toothed rollers forming a 10° cone around the feed path.

Rollers are driven through universal joints at the feed end and swing on spring-loaded arms near the cutters to adjust automatically to various diameter logs. Made by Mebro Ltd., Fife, Scotland, the machine debarks logs up to 8-in. dia. at 60 fpm.

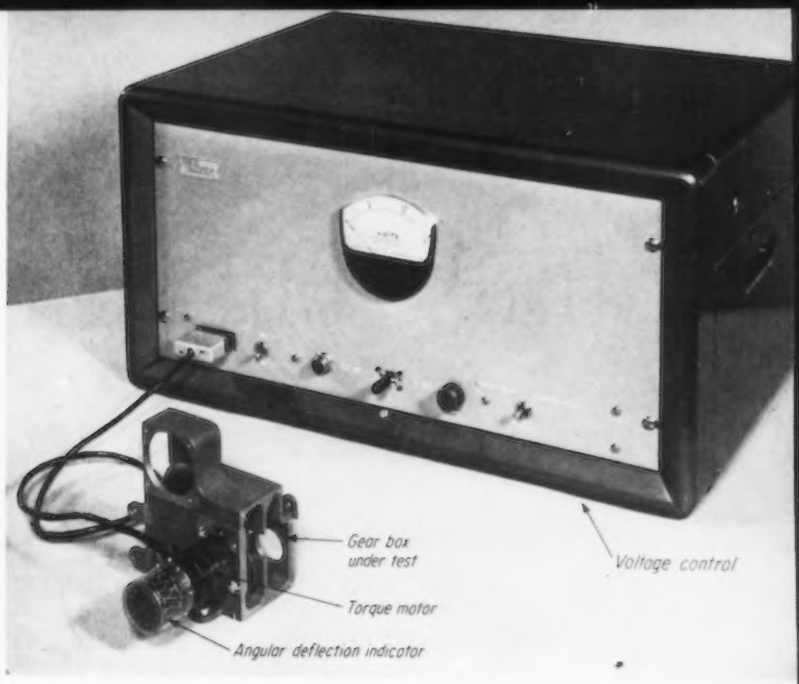




Roller and cutter countershafts . . . are driven with a flat belt that slips if cutters jam. This prevents damage from shock loads. Cutters are connected to countershafts with V belts; rollers are synchronized and driven by a chain drive. Rollers rotate log opposite to cutter rotation and feed it axially 1 ft for every 6 ft of peripheral motion past cutters. With this arrangement, a 2-in.-wide cutter contacts entire surface area. Cone angle of 10° is compromise for low log slip-back and reasonable length of feed rollers.



Spring-loaded arms . . . pivot on axes in line with those of universal joints that drive rollers. Top and bottom rollers extend past cutters and control feed after debarking starts. Side rollers are short to make space for cutters. Links connect each pivoted arm to compression springs in the frame. As log passes along feed path, it forces rollers out against spring forces until they adjust to its diameter. Long rollers and the cutters, which also pivot, are synchronized by stabilizer levers to keep logs concentric with passage through machine. Short rollers are stabilized by cutter mechanism until debarking starts, then disengage and swing free.



Dynamic Gear Tester

JACK BIEGER,
Chief Engineer
Daco Instrument Co., Brooklyn, N. Y.

Here is an electronic method that quickly analyzes instrument gear trains for (1) lost motion and backlash, (2) starting and running friction torque, (3) wear rate of gear teeth, and (4) effect of temperature changes on gear-train performance. Using torque motor and electronic voltage control, it also determines how much torque a safety clutch can take before it will start slipping.

The equipment, shown above, is essentially a torque applier. The 2-phase torque motor is attached to input shaft of the gear train and plugged into the control unit. The unit furnishes an adjustable voltage to the motor which in turn converts it into torque. A chart converts voltage reading to torque. The motor has an adjustable read-out dial—calibrated in degrees so that the angular displacement of the motor shaft can be read off easily.

CHECKING ON LOST MOTION

Causes of lost motion are: accumulation of backlash between mating teeth, twist in the shafts, bending in the gear teeth, play in the bearings, and shaft eccentricity. The over-all result is that, in operation, a certain amount of lag in the gear train will occur before the load begins to move. Specifications for a gear train should therefore include the permissible lost-motion value for a given torque.

To measure lost motion, the output shaft of the gear train is locked to prevent turning, and the torque motor is coupled to the input shaft. A specified torque is applied to the motor—which turns a certain amount and then stalls. The motor dial is adjusted at this point to give a zero reading. Then the motor is reversed. It will stall again and the total angular deflection (lost motion) can be directly read from the dial.

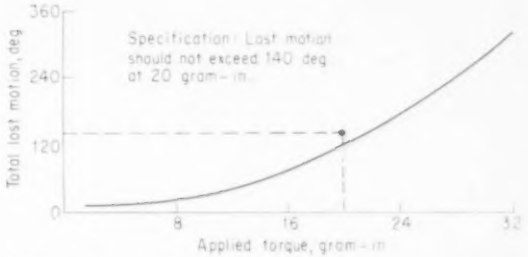
Wear rate of gear teeth can be determined by checking lost motion at intervals during life tests of the gear train. It can be assumed that increases in lost-motion values are caused by wear in teeth.

OTHER CHECKS

There are two types of friction torques. Both are checked without load on the gear train. **Static torque** is obtained by gradually increasing the torque until the motor just overcomes static friction and the gear train starts to move. **Running torque** is determined by gradually decreasing the torque, as the gear train is turning, until the motor stalls. Running torque will be somewhat less than static torque.

Effect of temperature on gear performance is also easily checked. A gearbox can be tested in a cold chamber and the effect of temperature on friction torque and lost motion measured.

Safety clutches are designed to slip when a certain torque value is exceeded. They can be adjusted in assembly, using the gear tester as an inspection check.



Lost motion goes up . . .
when gear train is operated at higher torque loads. This is typical performance for an 800:1 reduction 72-pitch instrument gear train; specification indicates maximum permissible value.

selection guide for Sandwich-Panel CORE

R. K. HUMKE, *Manager, Technical Service Lab.*
Adhesives Coatings and Sealers Div.
Minnesota Mining and Manufacturing Co.

Like sandwiches made in the kitchen to tease different tastes, sandwich panels are aimed at various design needs, and the filler is important. Here is a guide to the wide choice in core materials now available.

Novel materials have poured from research laboratories within the last decade, but almost as remarkable have been the many forms that materials have taken, and the new techniques for making structural composites from them.

An outstanding example is sandwich-panel construction—the laminating of thin facing materials with thick cores to give high strength-weight-ratio composites.

This technique has revolutionized design in the field of aircraft structures where metal honeycomb cores are now adhesive bonded, brazed, or welded to thin metal facings. But many other industries—from domestic appliances to marine—are also studying and using sandwich construction in new, often novel ways. In many cases, the materials were developed for other purposes—glass-reinforced plastic sheet and foamed plastics, for example—so data on their application to sandwich-panel construction is limited.

This article gathers together data on core materials, one of the key elements in any sandwich-panel application. Two articles in later issues will present data on facing materials and adhesives.

Most important function of the core is to stiffen and stabilize the two thin facings. The problem is one of optimum beam design: facings must be high-strength materials that will withstand outside fiber stresses; the core must make the transition from compression to tension and withstand maximum shear which occurs at the center. The joining agent—adhesive, brazing alloy or weld—must distribute stresses from core to facing panel.

Not all sandwich panels are load-bearing in the structural sense. Some are designed as thermal or acoustical barriers, others as weather shields or firewalls. The core materials discussed below are the most common, and the table on next two pages shows their widely varying properties.

Balsawood, one of the earliest low-density cores, has a high strength-weight ratio with high uniform tensile and compressive strengths. It is highly buoyant, has low thermal conductivity, is easily worked. For best sandwich strength, balsa cores should be so cut that grain runs perpendicular to the facing sheets. This limits panel size. Largest use has been in flat panels or straight beams but, with proper grain orientation, sandwich members with balsa cores can be formed into fairly severe curves. Like other woods, it can be sawed, planed, routed or drilled for simple assembly.

Balsa retains its properties indefinitely below 350 F; above, its strength, decreases rapidly, particularly if unsupported and exposed to air. Enclosed between metal facings, as in missile fins, balsa will withstand much higher temperatures. The three main disadvantages of balsa cores—combustibility, moisture absorption, fungus attack—can be minimized by chemically pretreating the balsa core, and edge-sealing the panel.

Low cost of balsa is a big asset and permits its use where the core volume is large, as in refrigerated trucks, tanks and storage rooms. Assembly of sandwich panels is with adhesives—water-base, solvent-base, or chemically curing. Porosity of balsa requires heavier adhesive film thicknesses than for other, more dense core materials. Glass fiber-reinforced facing panels provide their own adhesive by curing in place.

Plywood, common answer for suburban do-it-yourselfers, is often faced with aluminum or glass-reinforced plastic sheet for industrial purposes—packing cases and truck bodies, for example. For most core applications, exterior grade is suitable. Specific types are impregnated for weather resistance or fireproofing. Plywood does not delaminate easily, so holds up in high humidity and a wide range of temperatures. Hardwood veneer on one side and metal facing on the other combines decorative effects and sealing.

Hardboard, while a wood product, has wide application both as core material and as facing sheet. It is uniformly strong in all surface directions; will not split or splinter; resists denting, scratching and rot.

MATERIALS

Two basic grades are: standard hardboard, made by exploding wood fibers, then molding or pressing them into sheets with the lignin in the wood as cement; tempered hardboard, formed the same way except that a resin cement is used for better moisture and wear resistance. Metal facings are often used for both.

Standard hardboard tends to delaminate and swell with moisture, but adhesives will effectively seal the surface when facing materials are bonded to the core.

Tempered hardboard is less susceptible to moisture warpage, but is more expensive. Asphalt-impregnated wood fiber board is available for moisture resistance.

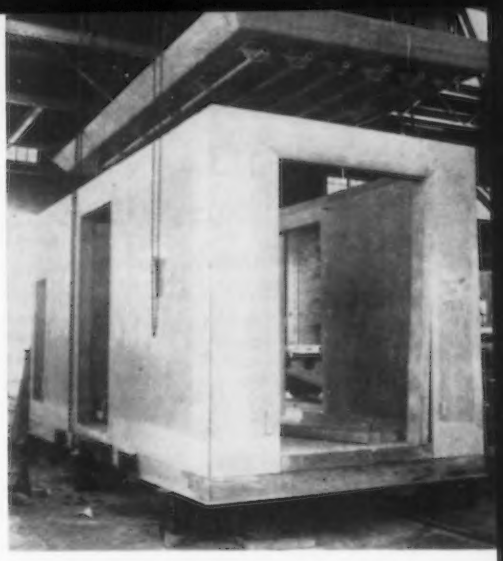
Kraft paper honeycomb, pound for pound, is the strongest, most economical core material known. The paper is corrugated and adhesive-bonded to form a continuous mat of hexagonal or bell-shaped cells. It can be bought in expanded or unexpanded form in various kraft paper weights, 80 to 120 lb. Unexpanded type is cheaper, but requires the user to provide additional manufacturing steps. For most structural panel coring, paper honeycomb is impregnated with 18-20% phenolic resin. This adds moisture resistance to the normal resistance to warpage, rot, pests and fungus.

Thermal insulation properties of panels with these honeycomb cores can be improved by filling the cells with various insulators such as the foam-in-place plastics and perlite powder. Common facing materials are aluminum and glass-reinforced plastics. Two examples of kraft honeycomb with plastic facing panels are airborne radomes and sailboat decking. Joints between core and facing are made with adhesives—usually applied by spraygun or roller.

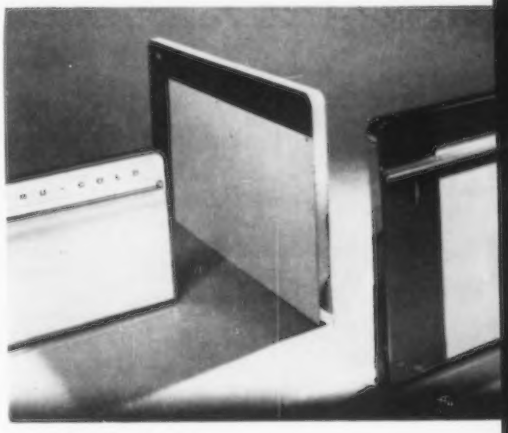
Impregnating paper honeycomb with a cement slurry is one technique for increasing fire resistance. While such cores lack the high strength properties given by resin impregnation, they are still practical. Humidity sensitivity of this core is high, so sandwich panels using it should be hermetically sealed.

Fireproof sandwich panels are mainly of interest in building construction, but firewalls are also needed for autos, small industrial furnaces, portable gas engines and the like. Here, inorganic cores of mineral origin are the most common. Ingredients are usually combined in cement form, either precast or cast-in-place. Additional fire resistance comes from the water content which must be driven off before core temperature will rise above 212 F. Common incombustible cores are: asbestos cement board, asbestos fiber silicate board, gypsum, and the lightweight concretes using perlite or vermiculite.

(text continued on page 74)



Balsa core . . .
cuts heat loss for this walk-in meat shipping locker made by Pullman-Standard Co. Fibrous glass reinforced plastic faces keep box light for trailer shipping and transfer by lift-truck.



Anodized aluminum . . .
and high-impact styrene faces team with Dow Chemical Co. expandable polystyrene beads in this freezer compartment door for 1958 Montgomery-Ward refrigerator.

Plywood core . . .
plus zinc-plated steel facings cuts costs and corrosion in truck floor. U. S. Plywood made the core.

CHARACTERISTICS OF CORE MATERIALS

	Material	Structure	Density, lb/cu ft	Tensile Strength, psi	Compressive Strength, psi	Shear Strength, psi
VEGETABLE	**Balsawood**	Fibers and ray cells	4–18	65–200 (⊥)[1]	300–1900 (∥) 40–180 (⊥)	130–385 (∥)
	Plywood: 3-ply fir	Sheet veneer bonded crosswise	29 avg.	1875–2190 (∥) 1875 (⊥)	1375–1600 (∥) 1375 (⊥)	180–210 (∥ and ⊥)
	3-ply particle board	Wood particles with thermosetting binder pressed into sheets	40	1875 (⊥)	2060 (∥) 530 (⊥)	212 (flatwise)
	Hardboard	Exploded wood fibers bonded with lignin	56–74	2300–6100	15,500–21,000 (flatwise)	3900–6800
	Paper honeycomb: Plain	Folded paper cells, ½–1⅜ in.	0.71–1.93	n.a.	10–85 (flatwise)	n.a.
	Resin-impregnated	Cell sizes: ½, ¾, and 1 in.	1.31–2.32	n.a.	45–135 (flatwise)	25 for 1 in. (⊥) 14 for 1 in. (∥) 65 for ½ in. (⊥) 36 for ½ in. (∥)
MINERAL	**Glass:** Fibrous	Matted batt with resin binder	0.6–3.0	Not used	Flexible	Not used
	Foamed	Expanded unicellular glass block	9	65	125	60
	Asbestos fiberboard	Fibers and silica compressed with inorganic binder	21–70	n.a.	n.a.	n.a.
	Aluminum honeycomb	Cell sizes: ⅛, 3/16, ¼, ⅜, and ¾ in.	1.6–8.0	n.a.	44–970, ⅜ in. bare; 62–1200, ⅜ in. with aluminum facings	36–428
	Glass fabric honeycomb: Plastic reinforced	Cell sizes: 3/16, ¼, and ⅜ in.	2.5–9.0	n.a.	125–2200, ½ in. bare; 193–2310, ½ in. with aluminum facings	68–430
FOAMED PLASTIC	**Polystyrene:** Pre-foamed	Rigid, closed cells	1.3–20	50–100	15–35 (0.5% offset)	25–45
	Foam-in-place	Rigid, closed cells	2–10	50–130	15–110 (0.5%) offset	28–120
	Vinyl	Flexible or rigid; open or closed cells	3.5–12.0	10–200	1.5–12 (for 25% set)	n.a.
	Urethane	Flexible or rigid; open or closed cells	1–30	2.5–200 (yield)	5–380	n.a.
	Cellulose acetate	Rigid, closed cells	6–8	158–183	197–235	140–185
	Phenolic	Rigid, with partly open and partly closed cells	1–20	4–75	9–130	8–120
	Epoxy	Rigid, closed cells	5–20	51 for 5.6 lb/cu ft 490 for 17.7 lb/cu ft	62 for 5.6 lb/cu ft 970 for 17.7 lb/cu ft	n.a.
	Silicone	Rigid or flexible; closed cells	6.5–20	n.a.	100–325	n.a.
	Urea	Rigid, closed cells	0.80	n.a.	n.a.	n.a.
	Synthetic foams: Phenolic micro-balloons	Gas-filled spheres embedded in resin base	10–40	300–900 (polyester-bound) 600–1000 (epoxy-bound)	1500–2700 (polyester-bound) 800–1500 (epoxy-bound)	n.a.
	Urea micro-balloons	Gas-filled spheres embedded in resin base	20–40	n.a.	up to 11,000	n.a.

FOR SANDWICH CONSTRUCTION

Elastic Modulus, psi x 10^4		Thermal Conductivity, btu/hr/sq ft/°F per in.	Moisture Resistance	Service Temperature Limit, F	Flammability	Dielectric Constant
Compression	Bending					
21–108 (‖)	21–83	0.30–1.24	Poor, special treatment or panel sealing required	350	Burns, unless specially treated	1.40
110 (‖) 92 (⊥)	160 (‖ and ⊥)	0.78	3.0–4.6 gr/sq ft/hr vapor transmitted	350 (intermittent)	Burns, unless specially treated	n.a.
27	160	1.06	Swells 3% by volume after 30 min. in water	Up to flash point of wood used	Burns slowly	n.a.
40–120	n.a.	0.78–1.50	Swells 5–18% by wt after 24 hr in water	250	Burns, unless specially treated	n.a.
n.a.	n.a.	0.20–0.55 (with paper facings)	Deteriorates	400 (intermittent)	Burns, but sandwich facings offer protection	n.a.
n.a.	n.a.	0.20–0.55	Retains 50% of strength when water-saturated	400	Burns, but sandwich facings offer protection	n.a.
Not used	Not used	0.22–0.27	Retains properties in water, absorbs 1% by wt	400–1000	Incombustible	n.a.
18	n.a.	0.39	Absorbs 0.2% by vol	700–800	Incombustible	n.a.
15 for 23 lb/cu ft 70 for 65 lb/cu ft	n.a.	0.55–1.80	Absorbs water; retains properties when dried	900	Incombustible	n.a.
n.a.	0.005–0.56	0.7–1.10 (with aluminum facings)	Impervious	350–400	Incombustible	n.a.
1.5–14	0.3–210	0.20–0.45 (with aluminum facings)	Superior to paper and resin-impregnated honeycombs	600	Depends on resin	1.11–1.15
750–1750	650–1900	0.23–0.28	Absorbs less than 1% by wt	175	Burns when exposed to direct flame	<1.05
19–260	n.a.	0.22–0.27	Absorbs 0.5% by vol	170	Burns when exposed to direct flame	1.02–1.24
n.a.	n.a.	0.23–0.31	Absorbs 0.1% by vol	200	Self-extinguishing	n.a.
n.a.	n.a.	0.20–0.30	Absorbs 2% by wt after 120 hr at 98% RH	250 (intermittent)	Self-extinguishing	1.06–2.85
0.55–1.35	n.a.	0.31–0.32	Absorbs 14% by wt at 100% RH	350	Burning rate 4.9 in./min	1.12
n.a.	n.a.	0.24–0.28	Absorbs 13–15% by wt at 100% RH	450	Burns slowly, unless specially treated	n.a.
1.01 for 10.3 lb/cu ft 2.7 for 17.7 lb/cu ft	0.27 for 5.6 lb/cu ft	n.a.	Excellent; no wt gain after 10 days at 100% RH	350	Burns, unless specially treated	n.a.
n.a.	n.a.	0.3	Absorbs 3% by wt after 24 hr in water	700	Incombustible	1.23–1.26
n.a.	n.a.	0.18	Absorbs 20% by wt at 95% RH	120	Self-extinguishing	n.a.
n.a.	n.a.	n.a.	n.a.	115–150	Burns	n.a.
n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

[1] Perpendicular to grain or cells; [2] Parallel to grain or cells; n.a.—not available.

Fibrous glass matted together in batt or carpet form, and bonded with varying percentages of thermosetting resin, is used for thermal and acoustical insulation. Unless resin additions are large, this material has little structural utility and serves mainly as fill between stiffened panels. Fibrous glass cores have been used mainly in sandwich panels for radomes. Fibrous glass-reinforced plastic sheets, on the other hand, make good facing panels for other core materials like balsawood and paper honeycomb.

Glass in foam form provides a rigid, waterproof, incombustible core, and is made by expanding molten glass to about 15 times its original volume. Resulting structure is closed-cell except at the surface. Foamed glass is made in blocks measuring 18 x 24 x 2 in., so cores must be laid up like brick with a rigid subsheet behind the skin—because of dimensional variations in the blocks and unevenness of layup. Brittleness requires that resilient adhesives like the neoprenes or nitriles be used. Cores of this material were thought to give limited fire protection because of thermal-expansion shattering and melting when exposed to direct flame. But tests show prolonged exposure to temperatures above 1350 F is necessary before damage occurs.

Glass cloth impregnated with thermosetting resin is available in honeycomb form as a sandwich core material. Here, the cloth is soaked with plastic, expanded to a honeycomb structure, cured, and successively coated with a polyester or phenolic resin to the needed thickness and strength. Either metal or glass-reinforced plastic facings can be used, with adhesive joining.

Metal honeycomb cores, like glass cloth cores, have been limited to aircraft applications because of cost. Here, the techniques have been developed to a high art. Metals most commonly used are aluminum and stainless steel, although development efforts on titanium honeycomb are continuing. Commercial applications grow as the cost drops. Some examples: exhaust-flue ducting, vacuum-system ducting, external pressure vessels, large fan blades and heat exchangers. Such structures are assembled by brazing, welding, and application of the many new structural adhesives, notably the epoxys. Current technology is being extended to ceramic honeycomb sandwich panels for ultra-high-temperature applications in the missile field.

Foamed plastics, precast or foamed-in-place types, are literally remaking the sandwich-panel industry. Simplification of manufacture is the main reason, and their range of useful properties is an added advantage. One example of manufacturing simplicity, well on its way to becoming a classic, is the 1957 Westinghouse freezer. Here, a long panel with polystyrene precast foam core and thin plastic facings is simply V-notched and folded to form the basic box. Addition of sandwich panels for back and door completes the structure.

Low thermal conductivity is a natural advantage of all foam plastics. They are also ideal for sandwich construction because of their good resistance to humidity and chemicals, light weight, good dielectric properties, and the good control of their density and mechanical properties possible in compounding. Greatest interest to date has been in the precast foams based on polystyrene, cellulose acetate, epoxy, urea, and phenolic formulations. Application of foam-in-place plastics—polystyrenes, polyurethanes, phenolics and silicones—has been limited to filling cavities of intricate shape; however, continuous foaming of polystyrenes and urethanes between adhesive-coated, colored aluminum strip is a reality, and these sandwiches will be in products like refrigerators and freezers before long.

Polystyrene foam is a rigid, closed-cell structure with low thermal conductivity. It is an effective insulator, particularly where the temperature differential crosses from warm humid conditions to cold areas with low humidity. Closed cells do not soak up condensation.

One of the lightest rigid cores available, this foam is easy to handle and machine, and won't crumble. It is available in precast planks, or in expandable beads for foam-in-place designs. The beads contain a blowing agent which expands with rising temperature. When heated in a confined mold, the beads can give intricate shapes of closely controlled density.

Assembly with this core usually uses adhesives of the water-dispersion or chemically curing types; adhesives high in solvent content will attack the cell structure, though bonding agents containing naptha and alcohol have been used. In such cases, most of the liquid vehicle should be allowed to evaporate before the sandwich is assembled, because the foam is nonporous.

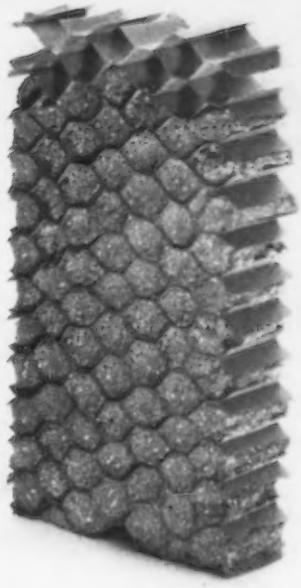
Rigid vinyl foams have good resistance to ozone, moisture, mildew, rot, and many chemicals. They can be precast or foamed-in-place. They soften with temperature increase, but are self-extinguishing when ignited. Primary emphasis has been on flexible, open-cell structures, either chemically blown or mechanically foamed. Closed-cell structures, which include the rigid varieties for sandwiching, are chemically blown from plastisols prior to complete curing of the slab. Principal sandwich applications include thermal and acoustical insulation, buoys, and other flotation items like liferafts and jackets. Since vinyls may be heat-sealed to themselves, large cores of complex shape can be assembled easily.

Urethane foams, in the rigid formulations used in sandwich construction, are closed-cell structures. Precast, or foamed-in-place by pouring or spraying, they have several advantages: high strength-weight ratio, excellent adhesion to many surfaces without bonding agent, low thermal conductivity, low water permeability, good resistance to oils and solvents.

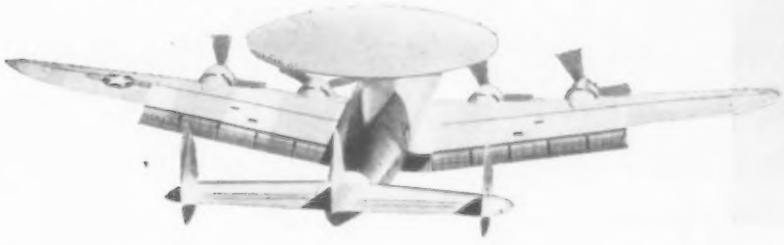
These characteristics, plus availability of easy-to-mix package foaming systems and decreasing cost, are widening the markets for rigid urethanes—particularly for foam-in-place cores. Examples: radomes and intricate aircraft structural components like trim tabs; double-walled thermal barriers in refrigerated tank cars, vacuum jugs, and industrial space heaters. Continuous casting of rigid urethane cores between metal strip stock has been developed. Post-curing at elevated temperatures extends cross-linking and increases strength, but elongation is slightly reduced.

Cellular cellulose acetate is a rigid-foam core material of high strength-weight ratio, low thermal conductivity, and good thermal stability—though it will burn rapidly when ignited. CCA is produced by extrusion, with

Foam plastic . . . ▶
adds thermal and acoustic insulation to paper honeycomb core with high strength-weight ratio. Union Bag and Paper Co.



Paper flying saucer . . .
houses radar on picket plane. Radome 30 ft in dia, made by Zenith Plastics Co., has paper honeycomb core with fibrous glass-reinforced plastic facings.



the unicellular structure formed by rapid evaporation of solvents during formation of the shape. Although length is unlimited, extrusion cross-section is controlled by die size—presently limited to about 6 sq in. This means that blocks must be laid up to form a core.

Facing materials commonly used with CCA are wood, metal, and resin-impregnated glass cloth or mat. Blocks can be cemented to facing sheet, and to each other, with high strength adhesives or with catalyzed monomers of polyester or epoxy resin. When the latter method is used, glass cloth or mat facings are easily laid on and the composite cured under pressure to form a rigid panel. Limited forming is possible, particularly if the extrusion skin is removed and wet heat applied during shaping.

Phenolic foams combine open- and closed-cell structure to give good thermal insulation as well as acoustic insulation. Along with properties common to solid phenolics, they have a wide range of controllable densities and low cost, making them ideal for sandwich construction. Though rigid, phenolic foams are not noted for structural strength, and are therefore limited to panels where the facings receive their main support by other means. The reactions used are rapid, so panel construction requires automatic equipment to time the several parts of the foaming cycle properly. Where the core must resist water vapor, phenolic foam is backed with metal foil or polyethylene.

Silicones give the only plastic foam with temperature resistance approaching that of the inorganic sandwich-core materials like glass foam and asbestos fiberboard. Heat-distortion temperature is over 700 F, and the plastic does not burn. Rigid silicone foams are available in precast or as foam-in-place powders requiring only the addition of heat for expansion. Chief disadvantages are high cost per pound, and a tendency to crumble when handled or worked. Sandwich structures are made with silicone rubber-based cements to obtain heat resistance of the composite structure comparable to that of the core. Primary uses to date have been aircraft.

Urea-formaldehyde foam exhibits the lowest density and lowest thermal conductivity of any core material listed, with the possible exception of paper honeycomb. This combination makes urea foams a natural as coring for sandwich panels in refrigeration equipment where portability is a factor, like trucks, shipping containers, and air conditioners. Low moisture absorption makes urea foams a more logical core material than paper honeycomb in such applications. Buoyancy is good, and all possible marine uses are now under development.

Epoxy foam, with excellent dimensional stability when exposed to elevated temperatures and humidity, is finding wide use as cores in plastic tooling. Here, the rigid precast foam is laid up in block form with epoxy adhesives and sandwiched between resin-impregnated glass cloth. Light pressure during cure between smooth templets gives a high finish to the composite. Resistance of epoxies to solvent attack permits such resin impregnation, and the open-cell structure of the saw-cut blocks serves to lock the facing panels in place. Sandwiches with aluminum faces have been made and are under evaluation.

Principal difficulty with epoxy foams is that they are difficult to make, with high exotherms that require care in castings—the reason why most foam-in-place formulations have been taken off the market. Although urethane foams have comparable properties and are easier to work with, epoxy foams have superior resistance to acids and alkalis, and development work is continuing on simpler casting systems.

Syntactic foams are mixtures of small, gas-filled spheres, or microballoons, and a resin base—polyester, phenolic or epoxy. Density is controlled by varying the ratio of spheres-to-resin, with spheres limited to a maximum of 40% by weight or 70% by volume. Sandwich construction is by hand-trowelling the mixture onto resin-impregnated glass cloth or mat laid up in a mold. After the putty-like mass is gelled, the second facing is laid up and the composite is cured.

how to design

MULTI-RATE HELICAL SPRINGS

The constant stiffness rate of a helical spring is sometimes a disadvantage. With these two little-known methods, springs can be assembled in series to give a rate that varies during operation.

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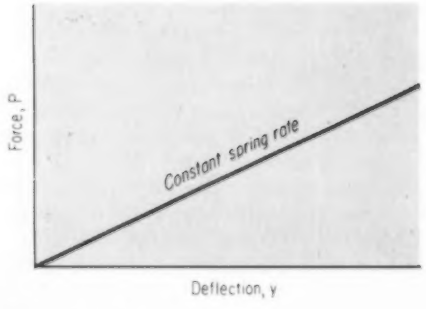
Supplying springs with variable rates of stiffness often improves the working characteristics of an assembly. With helical springs, of course, these rates are constant. But there are two little-known methods that will allow standard helical springs to be worked in series—in such fashion that multi-rate characteristics will result.

This approach can be useful for shock and vibration mounts, for aircraft and machine-tool systems. In aircraft, for example, the spring deflection in a control mechanism may correspond to an angular deflection of wing or rudder flaps. Deflections are small when wind loads are small—and here a stiff spring (high spring rate) gives the pilot a definite "feel" of the elements his wheel is controlling. But at higher deflections the flaps develop high wind loads; and now the spring should show a smaller spring rate that avoids a feeling of heaviness of the wheel.

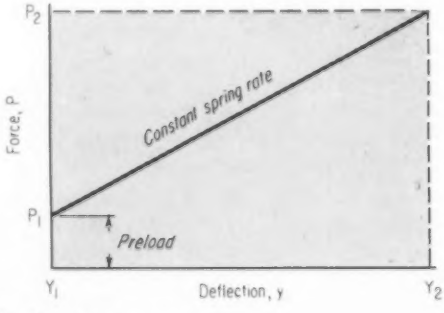
The two methods are:

1. Each spring, although in series, is preloaded separately. This method, which gives a decreasing spring rate, is shown in Figs. 1 through 6 and further illustrated by sample problem 1.

2. Two springs, each with different coil pitch, are combined in such fashion that the coils of one "bottom out" and become inactive after undergoing a certain amount of deflection. This gives an increasing spring rate. The method is finding increasing usefulness in front-end suspension systems of automobiles. The method is explained in Fig. 7 and sample problem 2.

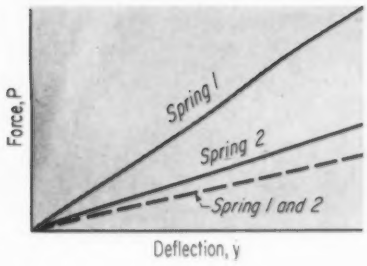


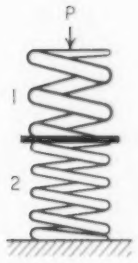
1 Spring rate *R* . . .
is the amount of deflection *y* produced by a load *P*; thus $R=P/y$. The spring rate is also known as the spring constant, spring gradient or spring modulus. For helical springs, the spring rate is constant, giving a straight-line curve on a force-displacement diagram.



2 Preloading . . .
prevents a spring from relaxing to its free-length position. Graphically, it shifts the spring-rate curve upward. Thus, there is a minimum load that must be overcome before the spring will begin to deflect. Spring rate now is

$$R = \frac{P_2 - P_1}{y_2 - y_1}$$

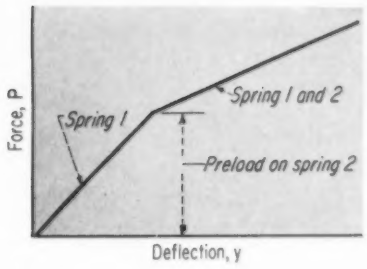


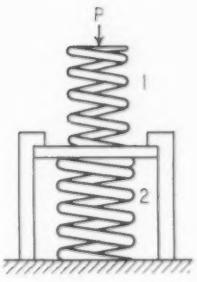


3 Springs in series . . .

will give a smaller spring rate than either alone. More specifically, for two springs with spring rates R_1 and R_2, the total spring rate R_t is:

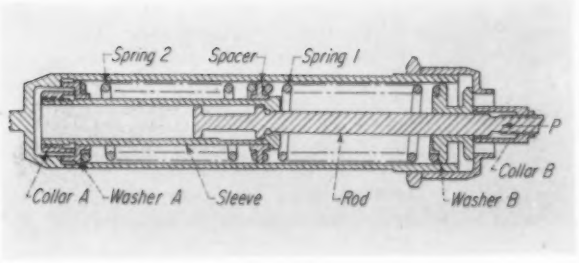
$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} \quad \text{or} \quad R_t = \frac{R_1 R_2}{R_1 + R_2}$$

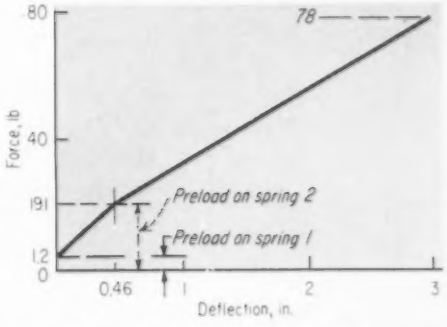




4 Multi-rate characteristics . . .

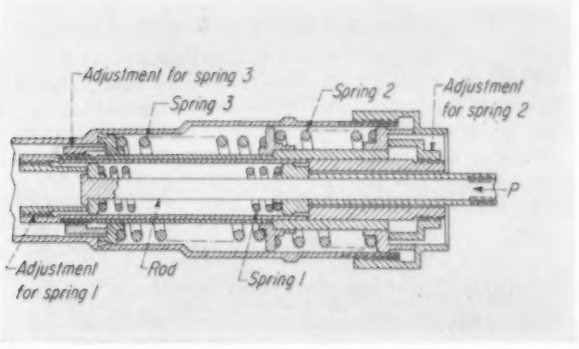
result when a preloaded spring is assembled in series with an ordinary spring in such a way that spring 2 is preloaded separately from spring 1. Preloading for spring 1 is optional. An increasing load or forced deflection on the system deflects only spring 1 until the load equals the preload of spring 2. At this point both springs begin to deflect, and the series characteristics give a total spring rate less than for either. Thus, the system operates with rate R_1 until the second spring cuts into the system (like throwing in a second resistor in a parallel electrical circuit), then the system operates at under rate R_t.

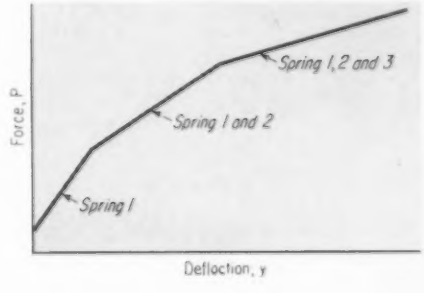




5 Double preload assembly . . .

designed for control systems of aircraft. The preload on spring 2 is obtained by turning threaded collar A on hollow sleeve. This forces washer A to the right, shortening the length of the spring. Preload on spring 1 is obtained by turning collar B to force washer B to the left. A load P deflects spring 1 until it overcomes preload of spring 2. At this point spring 1 moves the spacer to the left, loading spring 2. Values in the spring-characteristic curve above are used in sample problem 1 on next page.





6 Triple-rate assembly . . .

above uses three springs preloaded different amounts to give spring characteristics shown in chart at right. Spring 1 absorbs an increasing load P by itself until its deflection overcomes the preload of spring 2. At this point spring 2 begins to move. Springs 1 and 2 are now acting in series. Continued deflection finally oversomes preload of spring 3 and all three springs start working in series, shown above.

MULTI-RATE HELICAL SPRINGS (concluded)

SAMPLE PROBLEM 1

Springs 1 and 2 are to be installed with preloads of 1.2 and 19.1 lb respectively, into the mechanism in Fig. 5. The rod is to deflect 0.46 in. before building up to the preload of 19.1 lb. Total deflection is to be 3.0 in.; the load to be 78 lb at this deflection. Here is how to find dimensions of the springs.

1. Determine the spring rates:

$$R_1 = \frac{19.1 - 1.2}{0.46} = 39 \text{ lb/in.}$$

$$R_t = \frac{78 - 19.1}{3.0 - 0.46} = 23.2 \text{ lb/in.}$$

$$R_2 = \frac{R_1 R_t}{R_1 - R_t} = 57.3 \text{ lb/in.}$$

2. Verify the spring rates from the deflections of the individual springs:

$$y_1 = \frac{P}{R_1} = \frac{78 - 1.2}{39} = 1.97 \text{ in.}$$

$$y_2 = \frac{P}{R_2} = \frac{78 - 19.1}{57.3} = 1.03 \text{ in.}$$

$$y_t = 1.97 + 1.03 = 3.0 \text{ in.}$$

3. Determine the number of coils for each spring if $D=1.29$ for both springs, $d=0.148$ for spring 1 and $d=0.156$ for spring 2. ($G=11.5 \times 10^6$):

$$N = \frac{Gd^4}{8D^3R}$$

$$N_1 = \frac{(11.5)(10^6)(0.148)^4}{(8)(1.29)^3(39)} = 8.25 \text{ coils}$$

$$N_2 = \frac{(11.5)(10^6)(0.156)^4}{(8)(1.29)^3(57.3)} = 7 \text{ coils}$$

4. Allowing one inactive coil per end so that the ends may be squared and ground, the solid heights H of the springs are:

$$H_1 = (8.25 + 2)(0.148) = 1.517 \text{ in.}$$
$$H_2 = (7 + 2)(0.156) = 1.404 \text{ in.}$$

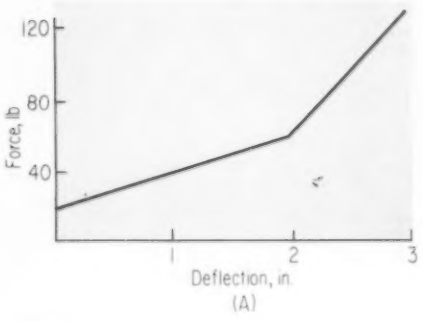
5. Assuming a coil clearance of three times the wire dia, then the coil clearances are:

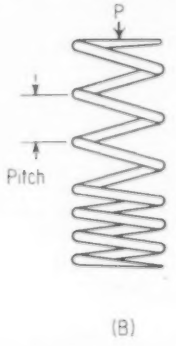
$$C_1 = (3)(0.148) = 0.444$$
$$C_2 = (3)(0.156) = 0.468$$

6. Free lengths of the springs are:

$$L_1 = 1.517 + 0.444 + 1.970 + (1.2/39) = 3.962 \text{ in.}$$
$$L_2 = 1.404 + 0.468 + 1.030 + (19.1/57.3) = 3.235 \text{ in.}$$

FOR INCREASING SPRING RATE





7 Two springs in series . . . will give increasing spring rate if lower spring has smaller pitch than the top spring. Under increasing load (A) both deflect until coils of lower spring "bottom out," leaving only the top spring operative. It is advisable, but not necessary, to preload top spring. In practice, assembly is simplified by using only one spring (B) with a varying pitch in the coils.

SAMPLE PROBLEM 2

Spring in Fig. 7 (B) is installed with a preload of 20 lb. It is to deflect 2 in. under a load of 60.6 lb and 3 in. under a load of 134 lb. The spring mean dia and wire dia are chosen as $D=1.69$ and $d=0.187$.

1. The spring rates are:

$$R_t = \frac{60.6 - 20}{2} = 20.3 \text{ lb/in.}$$

$$R_2 = \frac{134 - 60.6}{1} = 73.4 \text{ lb/in.}$$

2. The number of active coils are:

$$N_t = \frac{(11.5)(10^6)(0.187)^4}{8(1.69)^3\,20.3} = 18 \text{ coils}$$

$$N_2 = \frac{18(20.3)}{(73.4)} = 5 \text{ coils}$$

The spring will have a total of 18 active coils, 13 of which will bottom out when the load reaches 60.6 lb—leaving only 5 remaining coils operative as the spring compresses to final load of 134 lb.

3. Each coil will deflect same distance regardless of pitch; therefore deflection per coil at the 60.6-lb checkpoint is:

$$\frac{y}{N} = \frac{(8)(60.6)(1.688)^3}{(11.5)(10^6)(0.187)^4} = 0.166 \text{ in.}$$

To bottom out, the 13 coils will have a pitch of $0.187+0.166=0.353$ in. The remaining 5 coils must have a larger pitch to allow for additional buildup of 73.4 lb:

$$\frac{y}{N} = \frac{(8)(73.4)(1.688)^3}{(11.5)(10^6)(0.187)^4} = 0.200 \text{ in.}$$

The 5 coils must also have a coil clearance so that they do not close out. This clearance is arbitrarily selected as 0.050 in. The pitch of these coils will then be:

$$0.187 + 0.166 + 0.200 + 0.050 = 0.603 \text{ in.}$$

Thus, for 13 coils the pitch will be 0.353 in., and 0.603 for 5 coils. Only two different spring rates were employed in this example although it is quite easy to design the spring so that the pitch or spacing between the coils gradually varies to give a continually increasing spring rate. This type of spring finds wide application in shock-absorbing systems.

The Engineering Week has moved to a new position starting on page 17 where it is combined with Developments to Watch and Reader to Editor in a special eight-page section.

FOOT SWITCHES that can take it!

• **BUILT FOR THE TOUGHEST SERVICE** inside and out—from the maintenance free, snap action, double break, silver alloy contacts to the rugged, die cast aluminum housing—the redesigned Allen-Bradley Bulletin 805 foot switch is a challenge to tough jobs! The on-center treadle operation eliminates the need for bolting down the switch—the extended base keeps it from tipping.

• **VERSATILE OPERATION**—The contact trip point is easily adjustable. When equipped with two contact blocks, this foot switch can be set for simultaneous or two-stage operation. The Bulletin 805 foot switch can also be furnished with a latch to provide maintained contact operation. In addition, this latch, when desired, can be made inoperative, and may be quickly changed from one to the other side of the foot switch.

The Bulletin 805 housings are available for NEMA Type 4 watertight and oiltight applications, or NEMA Type 7 explosion-proof service.

Try the Allen-Bradley Bulletin 805 foot switch—you'll find it "tops" in its field. Send for full information.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

Bulletin 805 Style A switch with latch.

Bulletin 805 Style A switch with latch and top guard to prevent accidental operation.

Bulletin 805 Style A switch with latch and guard covering both top and sides.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

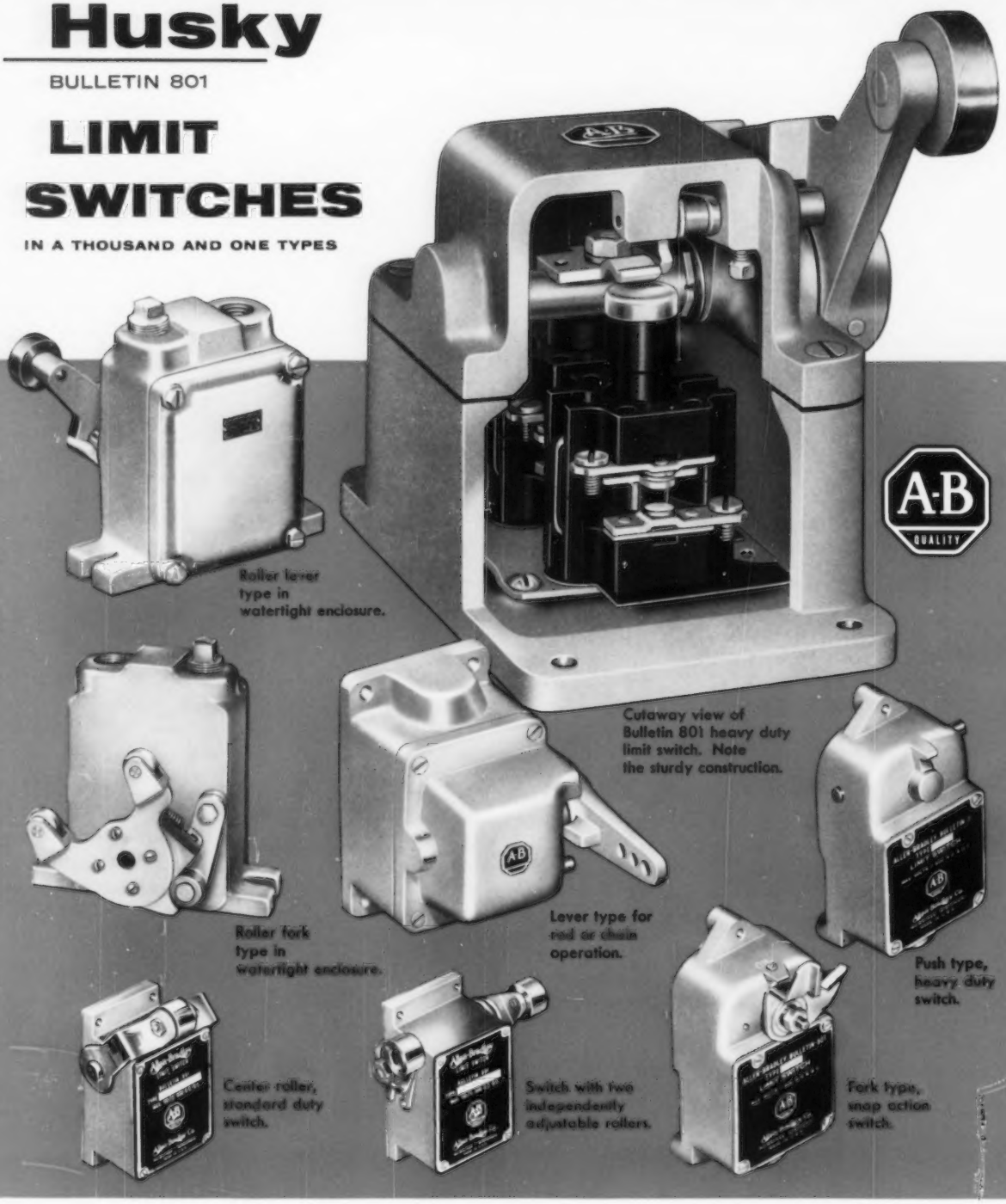
1-58-MR

Husky

BULLETIN 801

LIMIT SWITCHES

IN A THOUSAND AND ONE TYPES


A-B
QUALITY
Roller lever type in watertight enclosure.
Cutaway view of Bulletin 801 heavy duty limit switch. Note the sturdy construction.
Roller fork type in watertight enclosure.
Lever type for rod or chain operation.
Push type, heavy duty switch.
Center roller, standard duty switch.
Switch with two independently adjustable rollers.
Fork type, snap action switch.

From among the hundreds of Allen-Bradley Bulletin 801 general purpose limit switches, you're sure to find your exact requirements. There are 21 different contact arrangements available, including types with single or multiple poles, N.O. and N.C. contacts, spring return or maintained contacts, with either a slow or snap action mechanism. It will pay you to know this *quality* line of limit switches. If you do not already know this quality line, let's get acquainted. Write for the complete story.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

1-58-MR

New Rockwood Forged Ball Valves

8 Ways Easier to Handle!

New Rockwood Ball Valves are made of forged brass for greater tensile strength and safety. You're assured of Full, Round Flow and fast, efficient operation and less friction loss too.

The handle of the new Rockwood Forged Ball Valve can be positioned in 8 different ways *giving you greater convenience.* The ¼ turn opens and closes the valve — *giving you Full, Round Flow, efficient operation, less friction.* The pressure of fluid in the Rockwood Forged Ball Valve automatically positions the ball against the synthetic rubber seat — *giving you a leakproof seal.* The forged brass ball in the Rockwood Forged Valve is chrome-plated to stand up under abrasion, pitting, scratching — *giving you trouble-free service.*

The new Rockwood Forged Ball Valve comes in pipe sizes from ⅜" to 2". Tested and listed by Underwriters' Laboratories, Inc. Mail the coupon now for complete specifications and information.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
2248 Harlow Street
Worcester 5, Mass.

Send me illustrated folder on Rockwood Full, Round Flow Ball Valves.

Name.....

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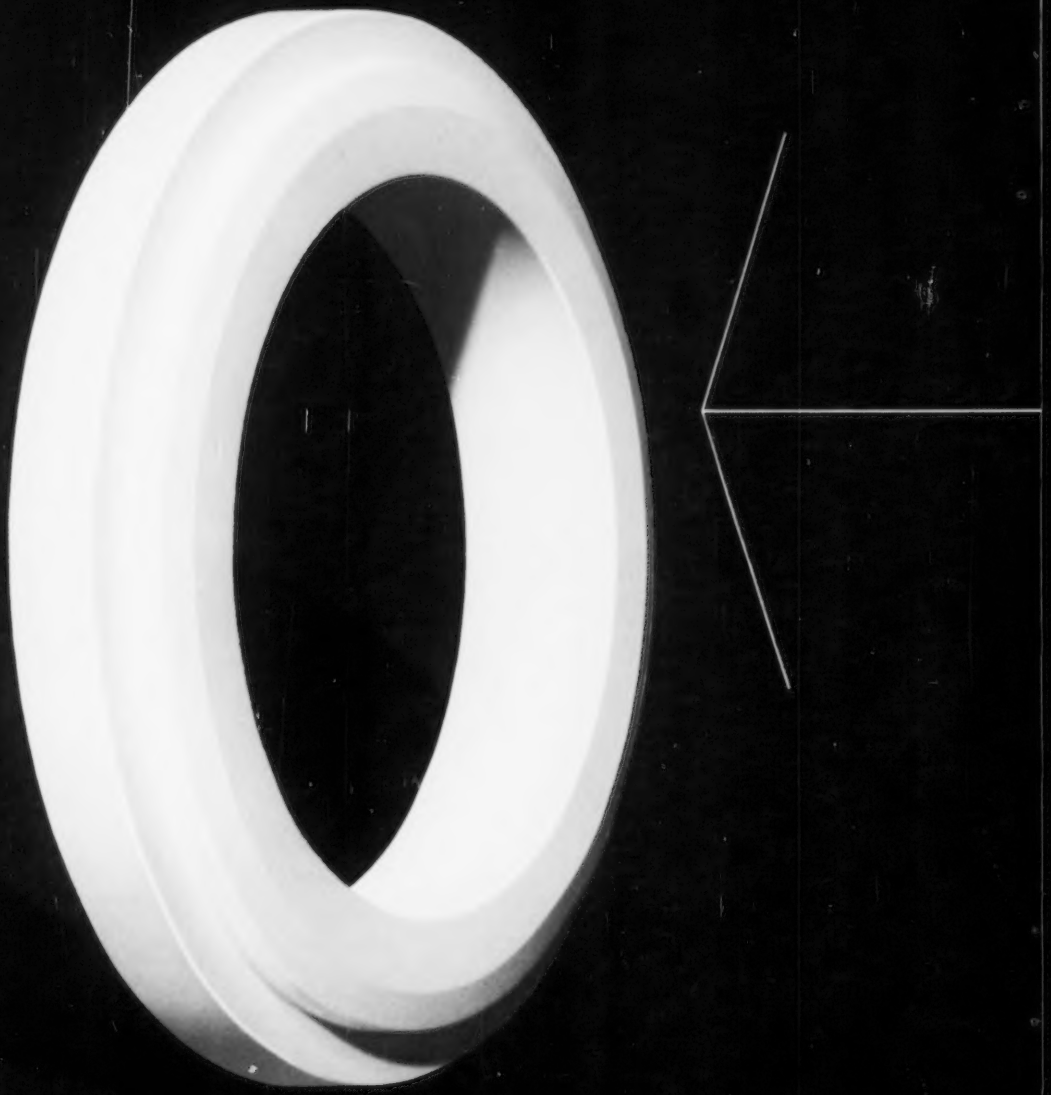
Company.....

Street.....

City.....

Zone.....State.....



THIS IS A COORS HIGH STRENGTH ALUMINA CERAMIC SHAFT SEAL RING FOR A 4" SHAFT

Coors CERAMIC

...how it solves problems of abrasion and corrosion

IN MECHANICAL SHAFT SEALS

Shaft seal rings for pumps and mixers are one of the many ways design engineers are using Coors High Strength Alumina Ceramic to combat corrosion and abrasion. The applications vary from large chemical handling pumps to water pumps for tractors and home appliances.

Solid ceramic shaft seal rings of Coors High Strength Alumina can be used in the presence of most liquids to include all acids except hydrofluoric. The material has a hardness greater than tungsten carbide. Seal faces are lapped to a flatness of two light bands or better, and surface finished for an extremely low friction coefficient. Any shape can be furnished that would normally be made on a lathe. Sizes for shafts up to 4 inches diameter are in regular production, and larger sizes can be supplied.

For testing design of parts, Coors can furnish small quantities of ceramic seal rings at nominal prices. For production quantities, thousands per day may be obtained.

MECHANICAL PROPERTIES

PROPERTY	UNIT	COORS Vitrified High Strength Ceramic TYPE AB-2
Tensile Strength	psi	17,000 - 18,000
Compressive Strength	psi	over 200,000
Flexural Strength	psi	42,000 - 45,000
Specific Gravity		3.40
Hardness	Mah's Scale	9
Maximum Working Temperature	°F	2550
Closest Machined Tolerances	inches	0.000020

DESIGN ENGINEERS—Coors High Strength Ceramic materials and Coors production facilities offer many product design possibilities to engineers where dimensional accuracy, corrosion, abrasion, and heat problems are a factor. For design details and complete mechanical properties, please refer to our 12-page catalog in Sweet's Product Design File.

MECHANICAL SEAL USERS—Mechanical shaft seals using Coors High Strength Alumina Ceramic may be obtained from most manufacturers of mechanical shaft seals.

COORS PORCELAIN COMPANY

Manufacturers of High Strength Alumina Ceramics

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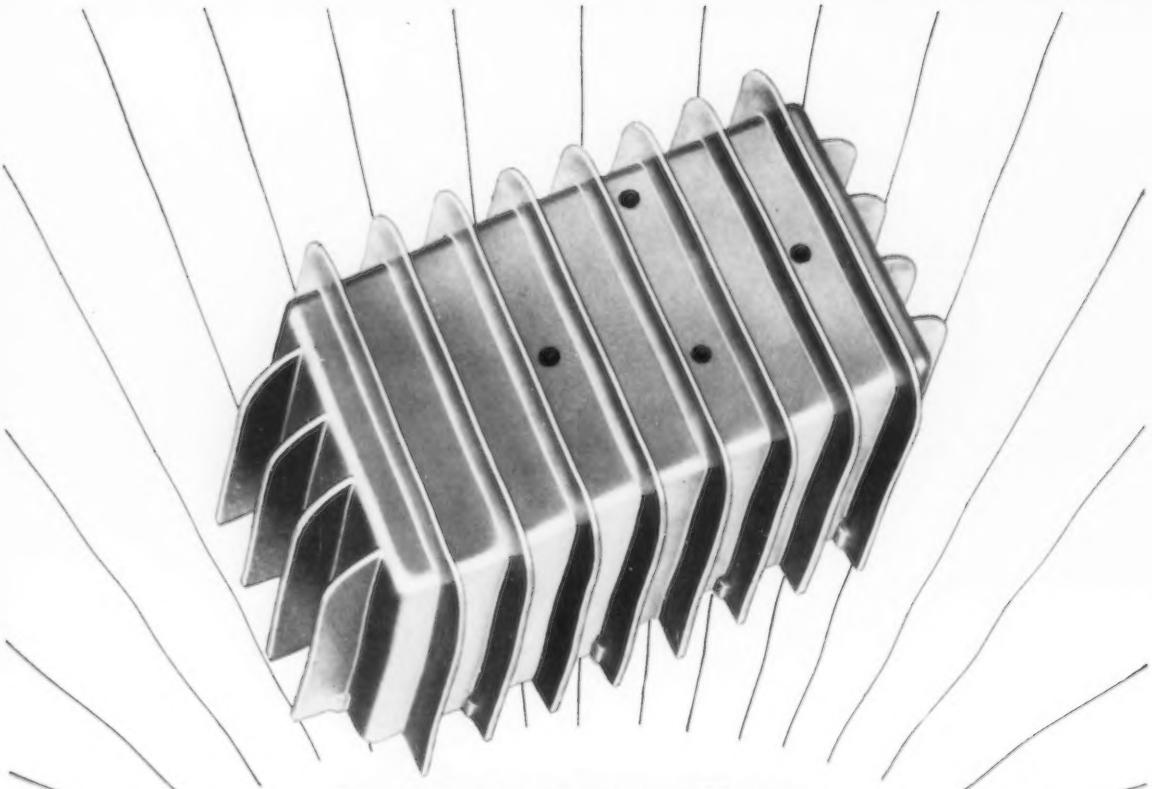

Multiple Operations
can often be reduced to **Two**
with **Madison-Kipp**
zinc and aluminum die castings

Tool designers, frequently, influence the selection of die castings to reduce tooling costs and to reduce the number of machine and assembly operations required.

Cooling fins, for instance, can be stamped and formed and assembled to a housing with multiple operations. Seasoned die designers and expert tool makers at Madison-Kipp can usually make a more efficient, stronger and lighter part in one die casting operation plus a fast trimming job.

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Please clip this ad as a reminder to contact us when you have die casting requirements.

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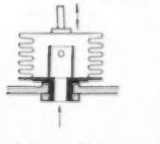
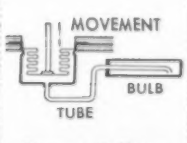
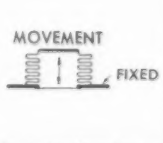


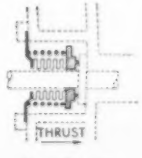
Pressure Motors



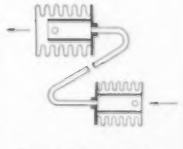
Thermostatic Motors



Expansion Chambers



Shaft Sealing

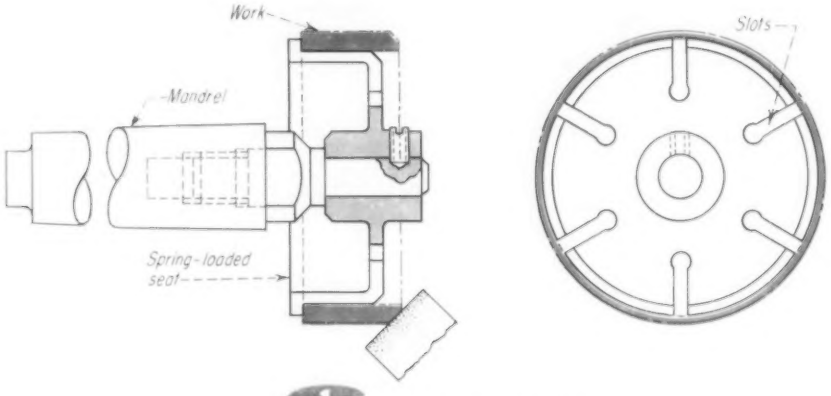

Remote Transmission

Expansion Joints

6 SPRING-LOADED CHUCKS (and) HOLDING FIXTURES

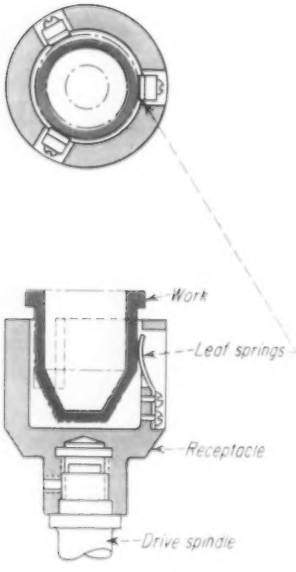
Spring-loaded fixtures for work-holding are sometimes preferable to other types. Their advantages are: Shorter setup time and quick workpiece change. And work distortion is much reduced because spring force can be easily and accurately adjusted.

Based on material in German, selected from "Federkraft-Spannvorrichtungen," Werkstatt und Betreib, No. 5, 1957.



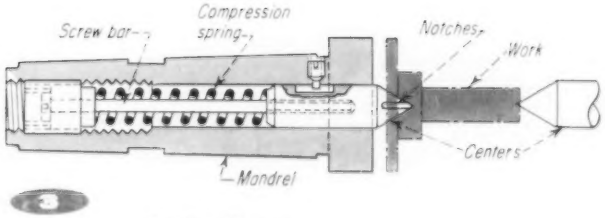
1

Spring-loaded Nest . . .
has radial slots extending into face. These ensure even grip on work, which is pushed over rim. Slight lead on rim makes work-mounting easier. Chief use of this fixture is for ball-bearing race grinding where only light cutting forces are necessary.



2

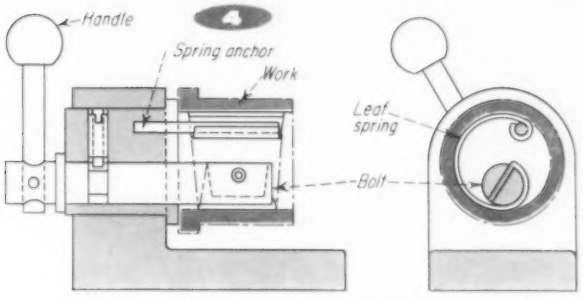
Cupped Fixture . . .
has three leaf-springs equally spaced in wall. Work, usually to be lacquered, is inserted into cup during rotation. Because work is placed in fixture by hand, spindle is usually friction driven for safety.



3

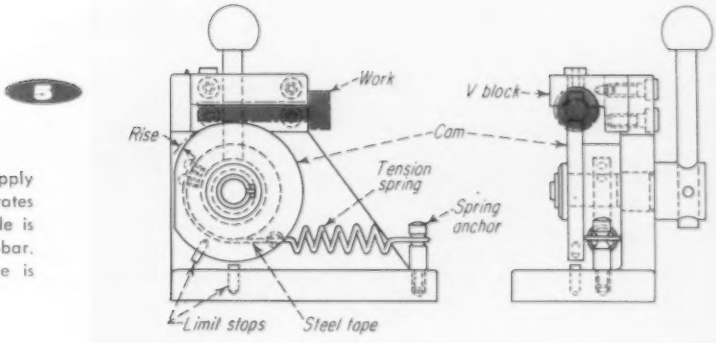
Lathe Center . . .
is spring loaded and holds work by spring pressure alone. Eight sharp-edged notches on the conical surface of driving center bite into the work and drive it. Spring tension is adjustable.

SIGMUND RAPPAPORT
Project Supervisor, Ford Instrument Co.,
Adjunct Professor of Kinematics
Polytechnic Institute of Brooklyn



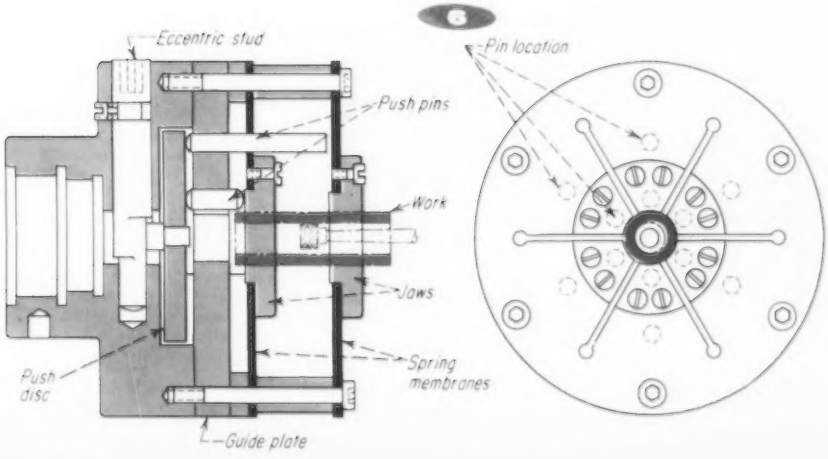
Leaf-spring Gripper . . .

is used mainly to hold work during assembly. One end of flat coil-spring is anchored in housing; other end is held in bolt. When bolt is turned, spring is tightened and its OD decreased. After work is slid over spring, bolt handle is released. Spring then presses against work, holding it tight.



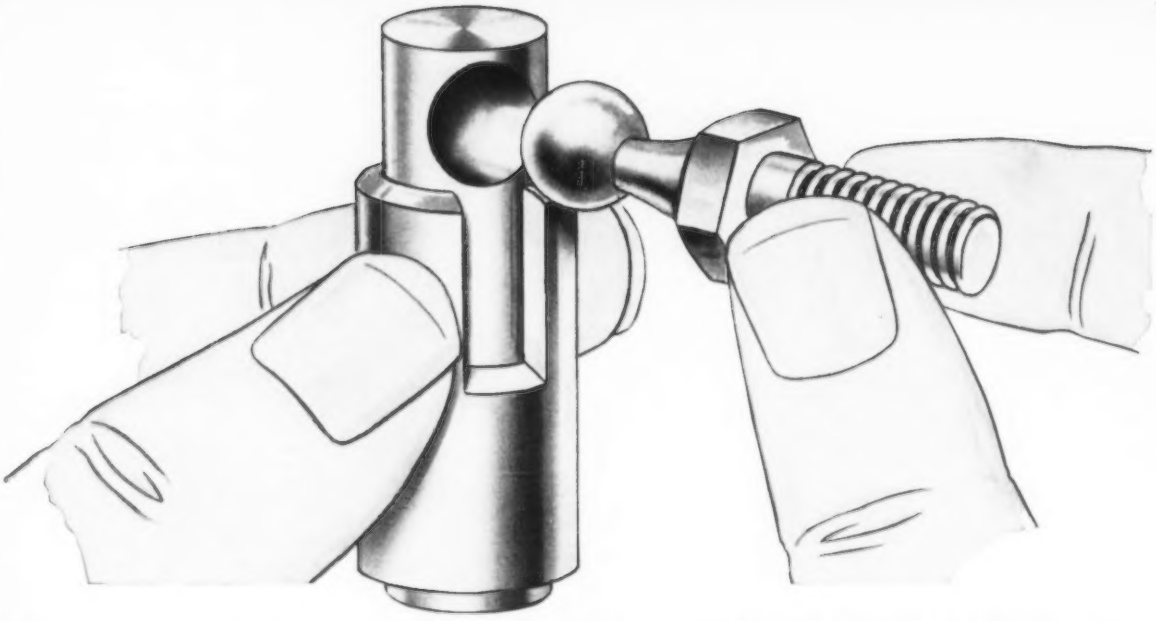
Spring Clamp . . .

has cam and tension spring to apply clamping force. Tension spring activates cam through steel band. When handle is released, cam clamps work against V-bar. Two stop-pins limit travel when there is no work in the fixture.



Slotted Membranes . . .

have holding jaws attached. ID of holding jaws hold work. When eccentric stud is turned it forces two sets of push-pins against the spring-membrane. This action deflects membrane, opening jaws for receiving or releasing work. Turning the eccentric stud back relieves the push-pins, allowing spring to snap back and grip work.



For Quick Assembly In Hard-To-Reach Places

NEW TOUREK SLIP-ON BALL JOINT

Precision-made for quick assembly in "hard-to-get-at places", or where adjustment of rod length must be made. Slight retraction of outer shell exposes the socket for quick insertion or withdrawal of the ball. Releasing the spring loaded shell returns it to normal operating position.

No pressure is placed on ball surface, thereby permitting free movement with approximately .004" end play. A minimum 15° movement in any direction is obtained in standard design. Side motion may be restricted for special applications.

TOUREK Slip-on Ball Joints consist of four component parts—1. Shell, 2. Outer Housing, 3. Spring, 4. Ball Screw. The shell is of rugged construction to give maximum strength in either direction. Ball screw wear surface is machined into the shell with tolerance for minimum end play. Outer housing serves three purposes: to retain Ball screw in the machined socket; to protect the spring from damage caused by exposure to foreign elements such as dirt and grease; to assure that the spring tension of the original assembly is maintained.

This design completely houses compression spring and retains the ball screw in its machined socket. Cotter pins, clips or other retaining devices are eliminated. No protruding sharp edges. No removable component parts which might become lost. Tampering with parts after assembly is minimized. A long wearing dependable assembly is assured.

This unit is supplied cadmium plated with the ball screw and wear surface on shell hardened. It may also be obtained prepacked with a lubricant. TOUREK Slip-on Ball Joints can presently be supplied to accommodate thread ranges from #10 to ½". If your applications require larger sizes or variations from our standard specifications, our engineers will gladly work with you.

Tourek
BALL JOINTS
The Recognized "STANDARD"

J. J. TOUREK MFG. CO.

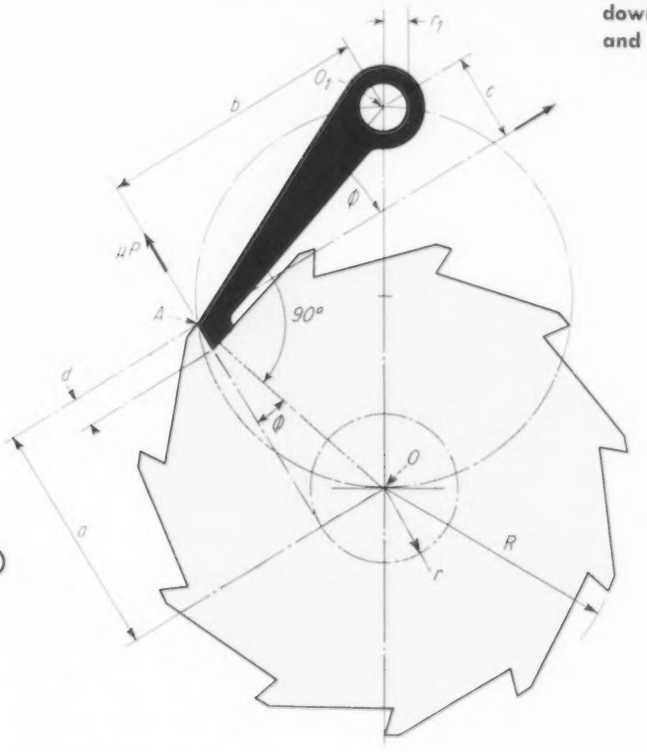
1901 SOUTH KILBOURN AVENUE, CHICAGO 23, ILLINOIS

World's largest manufacturer of "STANDARD" Ball Joints. Also makers of Pipe Plugs and quality Screw Machine Products. Range: up to 2⅝" diameter single and multiple spindle machines. Operations include: Threading • Tapping • Milling • Drilling • Grinding • Polishing • Plating • Heat Treating • Silver Soldering.

ESTABLISHED 1920

RATCHET LAYOUT ANALYZED

Here, in a brief but comprehensive run-down, are generally unavailable formulas and data for precise ratchet layout.



Pawl in compression . . .
has tooth pressure P and weight of pawl producing a moment that tends to engage pawl. Friction-force μP and pivot friction tend to oppose pawl engagement.

Symbols

a	= moment arm of wheel torque
M	= moment about O_1 caused by weight of pawl
O, O_1	= ratchet and pawl pivot centers respectively
P	= tooth pressure = wheel torque a
$P\sqrt{(1+\mu^2)}$	= load on pivot pin
μ, μ_1	= friction coefficients
Other symbols as defined in diagrams	

EMERY E. ROSSNER
New York, N. Y.

The ratchet wheel is widely used in machinery, mainly to transmit intermittent motion or to allow shaft rotation in one direction only. Ratchet-wheel teeth can be either on the perimeter of a disc or on the inner edge of a ring.

The pawl, which engages the ratchet teeth, is a beam pivoted at one end; the other end is shaped to fit the ratchet-tooth flank. Usually a spring or counterweight maintains constant contact between wheel and pawl.

It is desirable in most designs to keep the spring force low. It should be just enough to overcome the separation forces—inertia, weight and pivot friction. Excess spring force should not be relied on to bring about and maintain pawl engagement against the load.

To insure that the pawl is automatically pulled in and kept in engagement independently of the spring, a properly layed out tooth flank is necessary.

The requirement for self-engagement is

$$Pe + M > \mu Ph + P\sqrt{(1+\mu^2)}\,\mu_1 r_1$$

Neglecting weight and pivot friction

$$Pe > \mu Ph$$

or

$$e/b > \mu$$

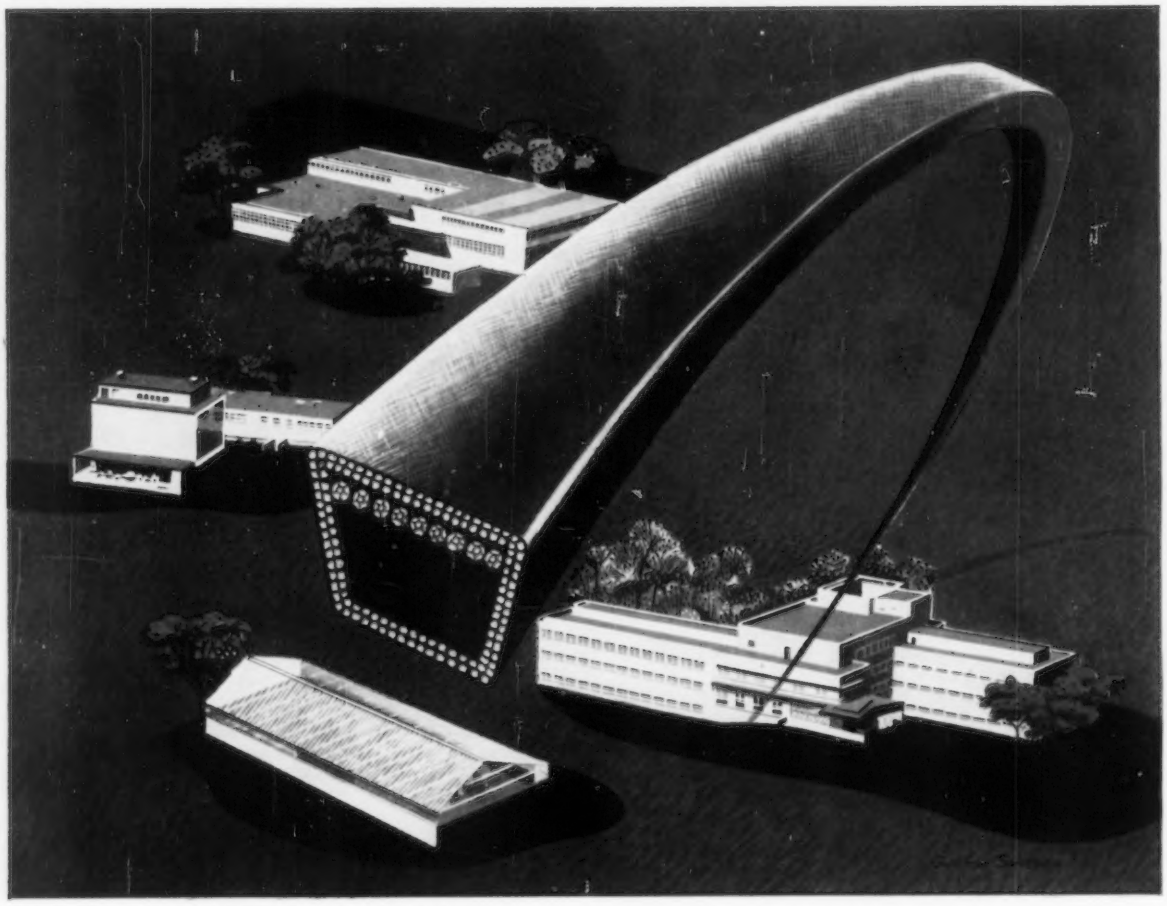
but $e/b = r/a = \tan\phi$, and since $\tan\phi$ is approximately equal to $\sin\phi$

$$e/b = r/R$$

Substituting in term (1)

$$r/R > \mu$$ (continued on page 91)

UNITENSION V-BELTS



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Mechanical Goods Division

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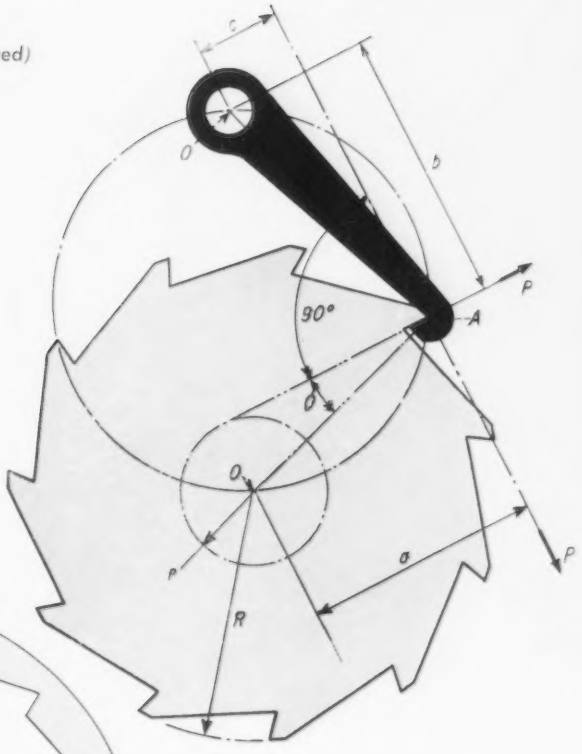
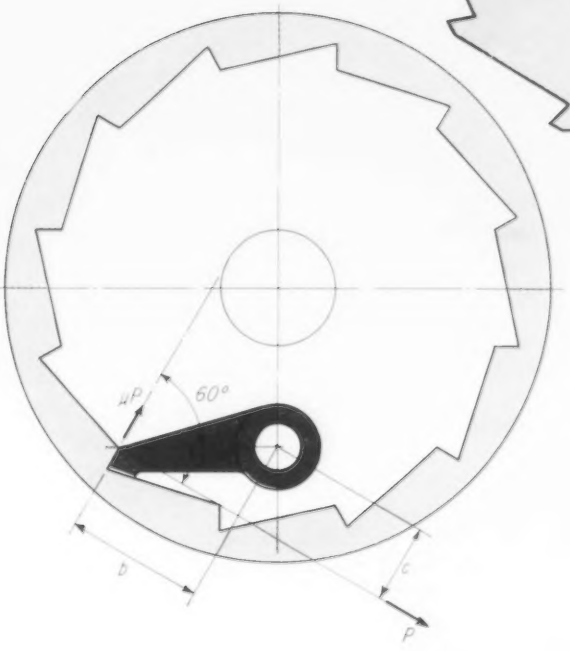
RATCHET LAYOUT ANALYZED *(continued)*

Pawl in tension . . .
has same forces acting on unit as other arrangements. Same layout principles apply also.





Inner teeth . . .
allow compact assembly of pawl and ratchet.

For steel on steel, dry, $\mu = 0.15$. Therefore, using

$$r/R = 0.20 \text{ to } 0.25$$

the margin of safety is large; the pawl will slide into engagement easily. For internal teeth with ϕ of 30°, c/b is tan 30° or 0.577 which is larger than μ, and the teeth are therefore self engaging.

When laying out the ratchet wheel and pawl, locate *points* O, A and O_1 on the same circle. AO and AO_1 will then be perpendicular to one another; this will insure that the smallest forces are acting on the system.

Ratchet and pawl dimensions are governed by design sizes and stress. If the tooth, and thus pitch, must be larger than required in order to be strong enough, a multiple pawl arrangement can be used. The pawls can be arranged so that one of them will engage the ratchet after a rotation of less than the pitch.

A fine feed can be obtained by placing a number of pawls side by side, with the corresponding ratchet wheels uniformly displaced and interconnected.

Need an invisible motor for your product...

FREE! Write for this 24-page booklet. It explains when to specify *Customized* motors, shows examples of design variations, illustrates case histories of *Customized* motors for actual products. Write Jack & Heintz, Inc., 17627 Broadway, Cleveland 1, Ohio

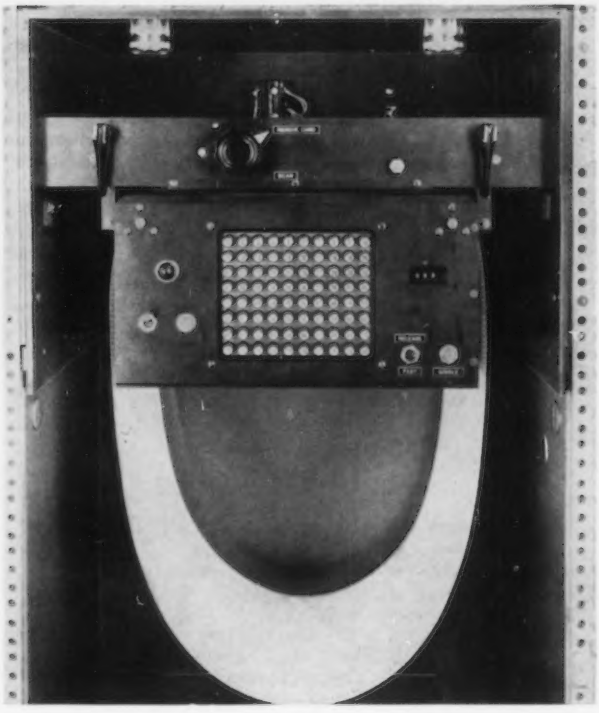
Call Jack & Heintz—America's leading specialist in *Customized* motors, $\frac{1}{8}$ to 5 hp ($\frac{1}{3}$ to 15 hp in submersible motors). We'll gladly devote as much time as it takes to make a motor so integral with your product as to make that motor invisible . . . a motor that *electrically*, *mechanically* and *physically* blends with and fits your product perfectly.

Customizing electric motors to meet the specific requirements of original equipment manufacturers *is our business*. Because we're organized that way, costs are reasonable to make a motor flush with a product or give it a special finish. We can stretch a motor tall, squat it flat, customize it for ambient temperature ratings. Make it submersible. Increase torque, reduce noise. You name it!

So, go ahead freely! Design your product to do its job. We'll fit a motor to it that will make your product perform the way you want it to . . . look as good as it should . . . last as long as you say it will . . . and sell faster because of it.

JACK & HEINTZ *CUSTOMIZED* ELECTRIC MOTORS

NEW COMPONENTS AND MATERIALS



Programmer Controls Up to 85 Circuits

This punched-tape reader uses a vinyl tape wide enough to provide 85 individual circuit-control channels. For each foot of tape length, there are 64 possible steps.

The unit's memory load relays are actuated by impulses transmitted through holes punched in the tape. The circuit controlled by one of these relays remains energized until a second pulse is transmitted through a subsequent hole in same channel. All circuits can be returned to normal at end of a cycle or from any control point.

Programmer is equipped with indicating lights that can be set up in connection with any steps in program. There are also pilot lights for each load circuit.

The reader, of modular design, will function from a variety of bases—analog, digital, temperature, feedback. A dual timer is offered as optional equipment, making it possible for the device to operate from a time base. In addition to the manual tape puncher presently available, an automatic unit will shortly be in regular production. Base price is approximately $4,000, and each circuit unit is $40 additional. Delivery, 100 days. **Industrial Timer Corp., 1407 McCarter Hwy, Newark 4, N. J.**

Circle 1, inside back cover

CONTINUED ON PAGE 94

Flow regulator . . .

that combines bypass and restrictor designs has a built-in relief valve. The unit can be used as a high-capacity relief valve, as a remotely operated relief valve, as a replacement for a power-steering pump or to provide small flow for a control system. It consists of a nonadjustable, bypass and restrictor type flow regulator and an adjustable, damped relief valve in a single housing. Port connections are for $\frac{1}{2}$, $\frac{3}{4}$ or 1-in. pipe. Max operating pressure is 3000 psi. Relief valve is adjustable within three ranges: 100 to 800, 250 to 1500 and 500 to 3000. **Fluid Controls, Inc., 1284 N. Center St., Mentor, Ohio.**

Circle 2, inside back cover

Multipurpose solenoid valves . . .

are two-way, normally closed, and have a plunger with a soft rubber seal. Said to be dependable for millions of cycles with full operation in any position. Internal construction is stainless steel; body is brass. Dimensions are 2.35 x 1.50 in. Orifice measuring $\frac{7}{64}$ in. is rated at 130 psi; $\frac{5}{32}$ in. at 60 psi. Designed for use with water, air, steam, inert gases, petroleum and vegetable oils, gasoline, kerosene and other semi-corrosive media. List price is $6.50. Stocked for immediate delivery. **Valcor Engineering Corp., Dept. 717, Carnegie Ave., Kenilworth, N. J.**

Circle 3, inside back cover

Strain-gage load cells . . .

for electrical measurement of forces and weights are in hermetically sealed housings. The nine available models range from 500 to 200,000 lb in capacity. Overload of 225% does not affect calibration. Cell cable has zero moisture absorption and a stainless steel jacket. **Cox and Stevens Electronic Scales Div., Revere Corp. of America, Wallingford, Conn.**

Circle 4, inside back cover

Reusable fitting . . .

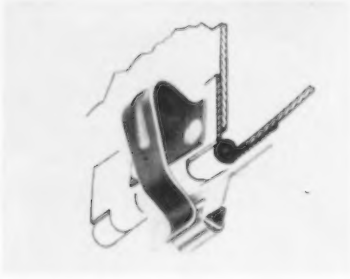
for high-temperature Teflon hose locks to the hose while the components lock to each other. Two seals designed into the fittings are actuated by internal pressure. Left-hand assembly threads prevent accidental loosening during installation. Criticals parts are hardened so the special fittings can be safely used again. Straight and elbow couplings in sizes from —3 through —20 are available. **Resistoflex, Roseland, N. J.**

Circle 5, inside back cover

Rubber compound . . .

is a medium-acrylontrile rubber with low "nerve" or springback in extruding, and low shrinkage characteristics in vulcanizing. Specially applicable to extrusion and calendering operations. Demonstrates excellent mill breakdown properties and accepts pigment readily. It is stabilized with a nonstaining antioxidant that supplements color of base polymer. Exhibits exceptional hardness and compression set and promotes smooth calendering, good mold flow and die reproductions, even in 40 to 50-Shore-A hardness. Applicable to crash-pad skins, seals, rings, gaskets, industrial tubing and hosing, belts and shoe soles. Available on commercial scale, packaging in 50-lb bales at prices following same schedule for other medium acrylontrile polymers in the company's line. **Chemical Div., Goodyear Tire & Rubber Co., Akron 16, Ohio.**

Circle 6, inside back cover



Door closer . . .

provides easy access to frequently used compartments. Developed for installation where space is limited. A hardened steel spring acting over a smooth brass roller makes up the closer. It resists vibration and is invisible from the outside. Available from stock. **Southco Div., South Chester Corp., Lester, Penna.**

Circle 7, inside back cover

Plastic gasket and shim stock . . .

in six basic gages with each thickness identified not only by color, but by gage number printed in over-all pattern. Sheet is impervious to oil and water, dimensionally stable, does not lose strength or form in service, is uniform in gage, and has a decomposition point in excess of 400 F. **Chicago-Wilcox Mfg. Co., 7701 S. Avalon Ave., Chicago 19.**

Circle 8, inside back cover

Expanded electric-motor line . . .

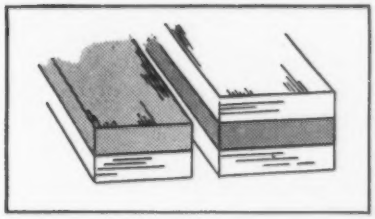
ranges from $\frac{1}{3}$ to 800 hp and has explosion-proof, totally enclosed and splashproof models. Included are fractionals from $\frac{1}{4}$ to 1 hp capacitor-start or polyphase-induc-

CONTINUED ON PAGE 96

BRIDGEPORT BRASS
COPPER ALLOY BULLETIN

Bridgeport Brass Co. Reporting New Developments in Copper-Brass Alloys and Metalworking Methods

Bridgeport Metal Laminates Open Up New Design Horizons



Bridgeport Metal Laminates offer outstanding design and production opportunities no single metal provides. Bonded in double or triple layers by a specially developed brazing process, they have exceptional shear strength, do not peel, chip or crack. Since the bond is a true metallurgical one, there is no porosity. Because of the variety of metals that can be bonded, laminates offer a limitless range of properties: "dual" corrosion resistance, improved electrical and thermal conductivity, greater strength-to-weight ratios, etc.

Combinations of copper, brass, stainless steel, Muntz metal, Monel, mild steel, iron and precious metals are some of the metals that are available in Bridgeport Metal Laminates.

In Duplex Laminates, either component can vary in thickness from .010 to 2 inches. They are made in sizes up to 30 inches square and, in many cases, even larger.

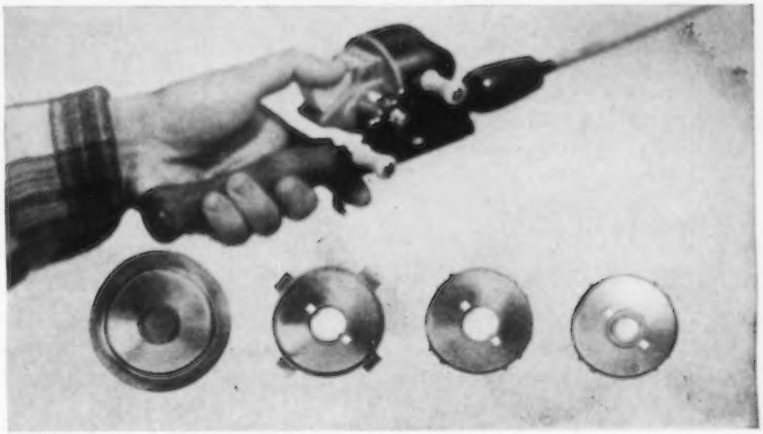
Triplex Laminates vary in component thickness from approximately .015 to 2 inches.

Applications for Bridgeport Laminates are many and varied—including copper/stainless steel frying pans, heat exchanger tube sheets, salt pots, electric terminal strips and contact parts.

Text samples of Bridgeport Metal Laminates are available through any Bridgeport Sales Office. Complete details on existing laminates and assistance on your special requirements are available through your Bridgeport Salesman.

For more complete details send for your copy of the new 12-page bulletin, BRIDGEPORT METAL LAMINATES.

Brass Alloys Add Extra Performance Factor to a "Failure-Proof" Fishing Reel



Shown are four progressive steps in manufacture of line pickup assembly for Bronson's Spin King reel.

Fishing for ideas? This reel life story may line up some for you

The Bronson Reel Company, Bronson, Michigan, manufactures the Spin King fishing reel. An extremely important part of the Spin King is the line pickup assembly which winds the line on the reel spool. Because of its unique, ingenious design, this pickup assembly can't twist and snag the line.

Uses Bridgeport Alloys

The pickup assembly is made from Bridgeport 37 (70-30 Cartridge Brass) and Bridgeport 6 (Free-cutting Brass) for an internal ratchet in the assembly.

Four steps are required to form the pickup before it is hard chrome-plated prior to final assembly. Starting with quarter-hard brass strip, the pickup is first blanked and partially formed as shown above. The second step calls for trimming and piercing, followed by a reforming operation. Finally, the assembly is ground to its exact outside diameter.

The serrated brass ratchet is milled and staked into the pickup after the latter has been plated.

Cartridge Brass Characteristics

The great strength and high ductility of Bridgeport 70-30 Cartridge Brass make it an ideal — and dependable — choice for this type of product. Operating without failure is one of the first demands made on this alloy. Its easy adaptability to successive and varied drawing, spinning and cold-heading operations makes it especially suitable for many finished products and components where these requirements are essential. Because of this, Bridgeport 70-30 Cartridge Brass is universally used for small arms ammunition, musical instruments, lamp reflectors and laboratory instrument cases of every description.

Free-cutting Brass offers similar advantages for parts that may require extensive machining. It's a high quality metal with excellent working characteristics.

Engineering Cooperation

The outstanding qualities of Bridgeport 70-30 Cartridge Brass or Bridgeport Free-Machining Brass may be just what you're looking for for your product or process. You can be sure that the full facilities of Bridgeport's Technical Service are at your disposal to help solve whatever copper alloy problems you may have. Your Bridgeport Salesman is your direct link to long experience and unparalleled research facilities. Call him today.

BRIDGEPORT BRASS

Bridgeport Brass Company, Bridgeport 2, Connecticut • Offices in Principal Cities
In Canada: Noranda Copper and Brass Limited, Montreal

tion models, and single-phase integrals from 1 to 5 hp. These are weatherproofed from all angles with frame mountings to meet new and old NEMA standards and have a sealed starting switch. Polyphase dripproof integrals from 1 to 800 hp meet present and old NEMA frame sizes. Increment-start models are also available. Jet-pump models from ½ to 3 hp have sealed starting switch. Single-phase models use 115 and 230 v; polyphase models use 208, 220, 440 and 550 v. Offered, too, are coupled pump motors from 1 to 75 hp, specially designed for centrifugal pumps. **A. O. Smith Corp., Electric Motor Div., Tipp City, Ohio.**

Circle 9, inside back cover

Two-way, high-flow solenoid valve . . .

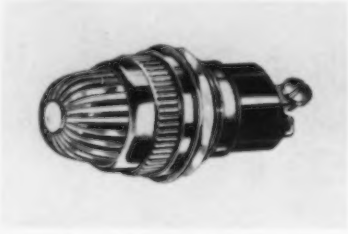
is normally-closed and pilot-operated. Valves weigh 1¾ lb and are 3⅞ in. high, but they give users a full ¼-in. orifice with ⅜ or ½-in. pipe taps. Only a small area of completely supported diaphragm is exposed to pressure. The synthetic insert is shockproof. A lifetime of millions of cycles through pressures ranging from 5 to 150 psi and temperatures from −40 to 180 F is reported. The valves can be mounted in any position. Body is forged brass; internal parts are stainless steel. **Skinner Electric Valve Div., 105 Edgewood Ave., Dept. L144, New Britain, Conn.**

Circle 10, inside back cover

Explosionproof temperature control . . .

is an uncalibrated unit. Settings are made by removing the cover and adjusting a hexhead screw. Any of three standard switches, normally open, normally closed or double throw with no neutral position, are available. All switches are single pole, suitable for 180-F ambient temperature and are rated for 15 amp, 115/230-v-ac service. Thermal system consists of a bellows in a housing and is filled with a temperature-sensitive liquid that activates a snap-action switch at the present temperature. Models are available with adjustable ranges between 0 and 425 F with On-Off differentials of approximately 3 and 6 F for circulating air; 1 and 2.5 F for circulating liquid; 6 and 15 F for gravity air. Type C95, of cast-iron construction, weighs about 4½ lb. **United Electric Controls Co., 85 School St., Watertown, Mass.**

Circle 11, inside back cover



Oiltight indicator lights . . .

have built-in resistors for use with neon glow lamps on voltages to 250 v. Components are of one-piece brass and are fully gasketed. All gaskets are retained, preventing loss of seal. Stovepipe lens is fluted and provides visibility from any direction. May be specified as plain, unfrosted or with frosted back. Choice of seven lens colors. Terminals may be screw or soldering type. Mounts in 1⅛-in. clearance hole. **Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.**

Circle 12, inside back cover

Miniature mechanical differentials . . .

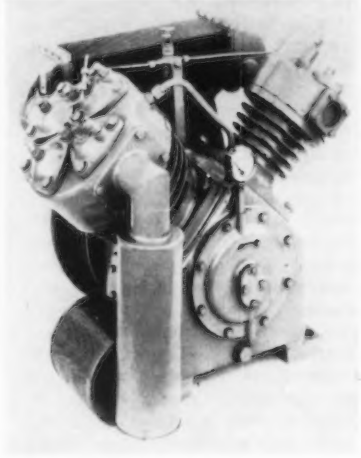
produce algebraic sum or difference of two speeds in the form of output-shaft rpm. Each unit contains two ac or dc motors and a gearing unit. Typical performance is from 5 rpm clockwise through 0 to 5 rpm counterclockwise with 300 oz-in. torque. Speed is from 10 to 100 rpm in either direction; torques to 2500 oz-in. are possible with smooth changes through zero at full torque. Present applications are in antenna drives, tracking devices or digital-to-analog mechanisms. Package size varies with motors selected. **Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.**

Circle 13, inside back cover

Electric motors . . .

in aluminum frames, sizes 182 through 326U, and rated at ½ through 40 hp are available in dripproof or totally enclosed fan-cooled models. Design permits standard power-package adaptations with fluid couplings, gear reducers and magnetic brakes. NEMA face and flange endbells are provided. **Reuland Electric Co., Alhambra, Calif.**

Circle 14, inside back cover



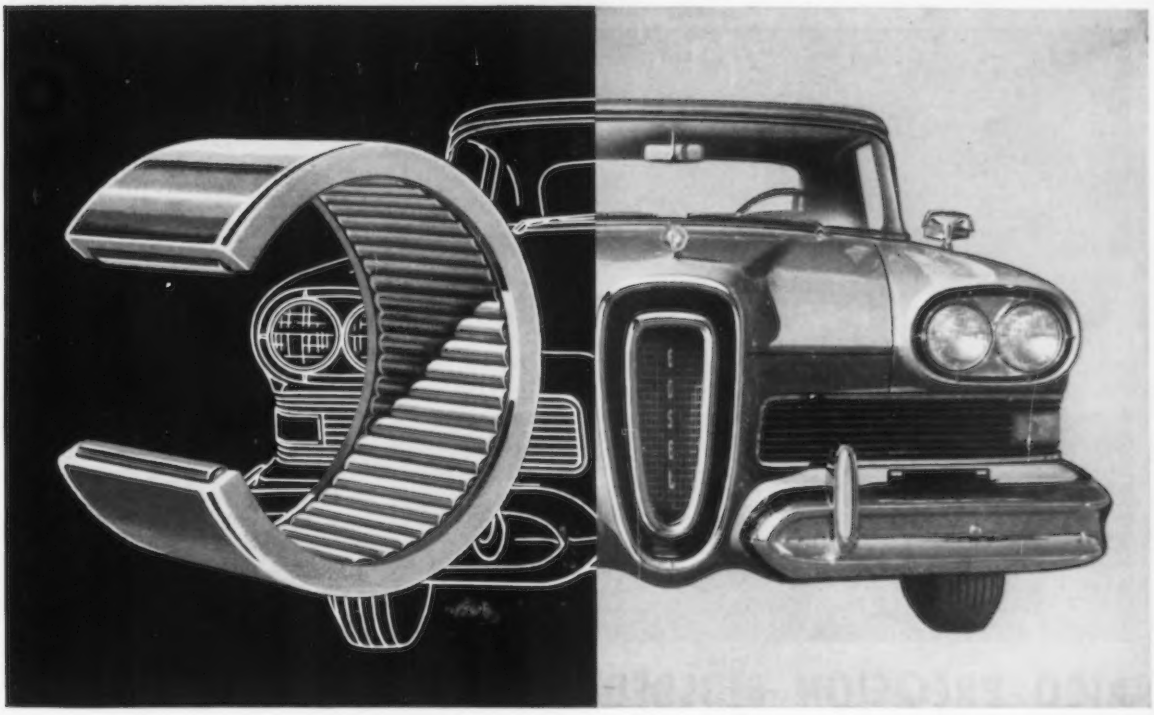
Continuous-duty air compressors . . .

delivering from 47 to 105 cfm of air at pressures of 100 psi are designed to be mounted on machines or to supply equipment air requirements.

Ranging in weight from 440 to 595 lb,

CONTINUED ON PAGE 98

America's newest thin-shell needle bearing



. . . now in America's newest automobile

Developed with the cooperation of Ford Motor Co., these KAYDON bearings are used in the automatic transmissions of Edsel as well as Ford and Mercury

The 1958 Edsel, America's newest automobile, backed by more than 1,250,000 road-test miles, employs in its transmission, America's newest thin-shell needle bearings, introduced by Kaydon of Muskegon. Why?

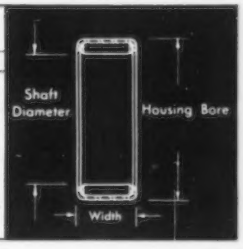
Proven in Ford-O-Matic and Merc-O-Matic transmissions, these Kaydon thin-shell needle bearings deliver 46% more bearing capacity.

Greater effective length of spherical end rollers does it. Important too, simplified construction, pre-packed lubrication, saves money . . . and saves valuable time on the assembly line too! See table below for standard Kaydon thin-shell needle bearing sizes.

AVAILABLE FROM STOCK IN 5 STANDARD SIZES:

SHAFT DIAMETER	HOUSING BORE	WIDTH
1.0605"	1.3130"	.500"
1.1250"	1.3755"	.750"
1.1250"	1.3755"	1.000"
1.1875"	1.5005"	.625"
1.3750"	1.6875"	.625"

For other sizes and complete specifications, write or call KAYDON of Muskegon today.



THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

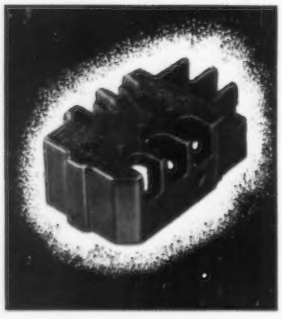
K-573

All types of ball and roller bearings — 4" inside diameter bore to 160" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

the "Bargain" in Custom Molded Plastics that Saves You This Money...

is No "Bargain" if You Waste This Money on the Assembly Line

AICO PRECISION MOLDED PLASTICS COST LESS IN THE LONG RUN



A supermarket of custom molded plastics, Aico has the facilities and coordinated skills to provide you with precision molded plastic parts to satisfy your most exacting requirements. Aico plastic parts are ready for fast assembly into your product on delivery . . . with physical properties, dimensional stability, and required inserts according to the most rigid specifications. Aico precision molded plastics cost less in the long run because you get Aico efficiency and quality from start to finish.

AICO The Supermarket Of Custom Molded Plastics

Aico's complete plastics molding service includes Engineering, Mold Building, Compression, Transfer, Plunger, Injection and Cold Molding . . . plus the molding of Reinforced FiBeralas.

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..... Have Aico representative call on me.

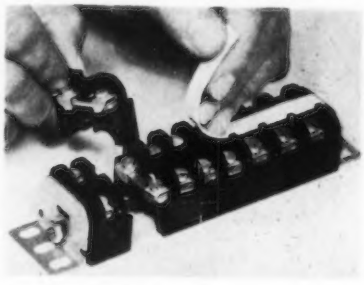
they may be installed as stationary or portable units. All models are air-cooled, two-stage, two-cylinder, single-acting machines. Connecting rods operate a single crank. Bearings are pressure-lubricated from a gear-type pump operating from end of the crankshaft. Automatic unloading is accomplished by air-operated plungers that hold suction valves open during compressor idling periods; compression is resumed when air receiver pressure falls to preset level. Can be coupled directly to high-speed electric motors or for V-belt drive from higher-speed motors or diesel engines. Also available in power-pack units. Unit size ranges from NT-7, 25 x 25 x 29 in. over-all, to NT-9, 29 x 30 x 34 in. **Atlas Copco Eastern, Inc., 151 Linwood Ave., Paterson, N. J.**

Circle 15, inside back cover

Rotary face seals . . .

for use in difficult sealing situations involving high-speed shafts, operate in temperatures from —320 to 1200 F. Bellows spring seal is a machined part without any opening. Facings of carbon, tungsten-carbide or other suitable materials, are held by bellows spring against rotating face of a shoulder machined as an integral part of shaft. **Skinner Seal Co., 3001 Sutter St., Santa Ana, Calif.**

Circle 16, inside back cover



Terminal block . . .

for custom assembly or in factory-assembled strips rated at 600 v ac or dc, 15, 25 and 50 amp. Snap-in marking strip and snap-on terminal block facilitate modification. No special mounting rods are re-

(Continued on page 102)

Golden year for... BLACK MAGIC

In our 50 years of manufacturing dispersions of colloidal graphite, we've seen the unique anti-friction properties of this basic material make lubricating problems disappear as if by "black magic". As an additive to lubricating oils and greases, as a parting agent in many kinds of casting and as a dry-film lubricant in diverse fields of metal working . . . in application after application . . . it has proved literally more valuable than gold.

Dr. Edward Goodrich Acheson's invention of colloidal graphite over 50 years ago has been followed by a constantly expanding program of fundamental research and product development. Today, with over 50 different dispersions already in use, three laboratory groups at Acheson are pressing toward perfection of whole new families of dispersions and their applications.

The custom dispersing of solids requires specialized facilities and production techniques. Why not take advantage of Acheson's 50 years of leadership in this field?

You will be interested in the number of different dispersed solids, in addition to graphite, that are being used successfully today in industry. Our Products List gives you, in quick-reading chart form, a résumé of Acheson 'dag'® brand dispersions and their typical applications. Send for your copy. Address Department PE-18.

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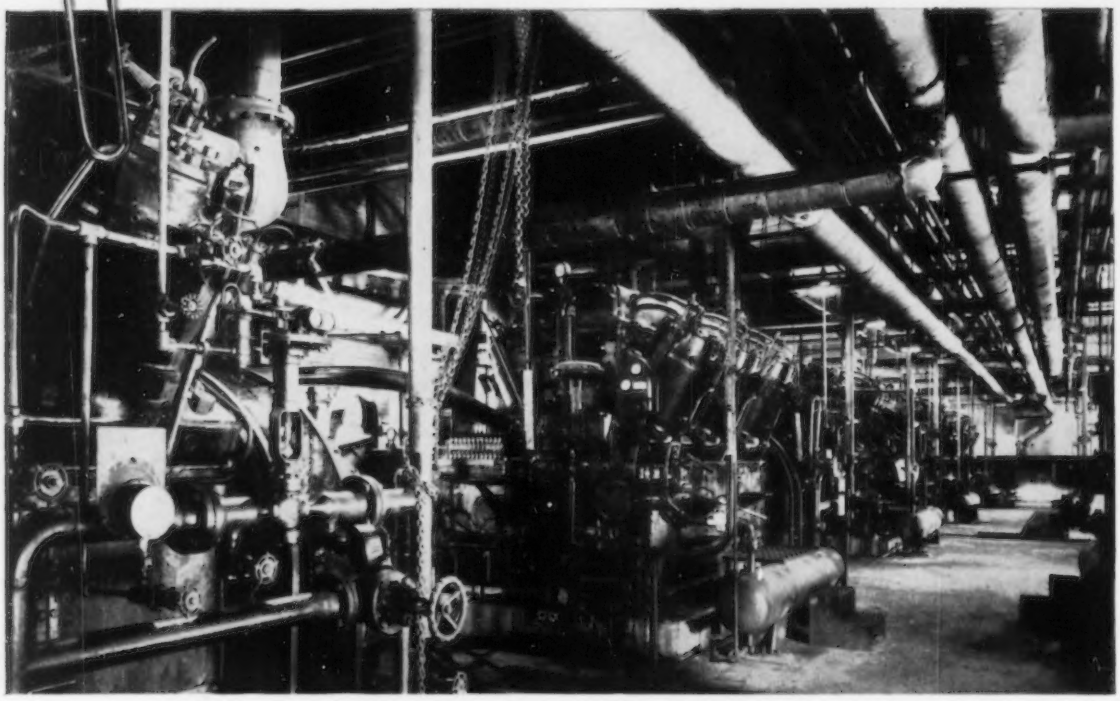
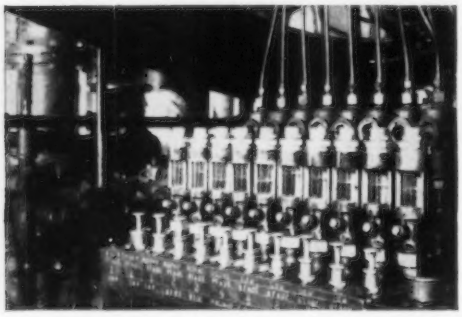
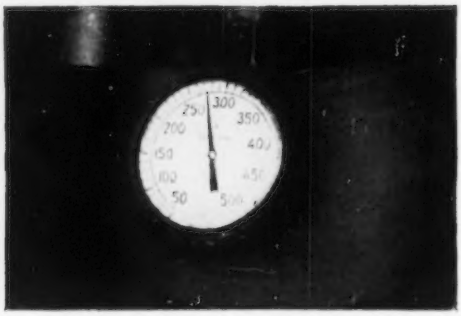


" . . . Cellulubes were tested for two years in four Cooper Bessemer Air Compressors. Cylinder wear was negligible. Deposits normally found in compressor auxiliaries and valves were reduced or eliminated."



" . . . A conventional lubricator will pump Cellulubes satisfactorily. No obnoxious vapors—does not present a personnel problem in terms of handling a toxic material."



" . . . No pressure surges nor evidence of fire in the air accumulator when Cellulubes are used. They are excellent lubricants, and also are effective as detergents."

CELANESE CORPORATION OF AMERICA, CHEMICAL DIVISION
DEPT. 547-A 180 MADISON AVENUE, NEW YORK 16, N. Y.

Please send me:

☐ Technical bulletin ☐ Sample of_____viscosity.

Name_____ Title_____

Company_____

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Application I have in mind_____

From a trial file covering two years testing in Cooper Bessemer 3-stage air compressors

"NO PRESSURE SURGES...NO EVIDENCE OF FIRE... EXCELLENT LUBRICATION...WHEN FIRE-RESISTANT CELANESE CELLULUBES ARE USED!"

"Cellulube has now been in four of our Cooper Bessemer air compressors for approximately two years. The compressors were inspected during a recent Catalytic Reformer General Inspection. Cylinder liner wear was negligible, particularly when compared to the amount of wear we had experienced when previously using a synthetic lubricant. Cellulube, in addition to acting as a lubricant, is also effective as a detergent. Compressor cylinder air passages which had been heavily coated with carbonaceous materials and deposits laid down by the previous synthetic lubricant, are gradually being removed and the compressors again show the original factory finish. Deposits on valve cages and plates have been reduced and are no longer a problem.

"Cellulube does not present a personnel problem in terms of handling a toxic material. There are no obnoxious vapors from Cellulube. A conventional lubricator will pump Cellulube satisfactorily.

"There have been no pressure surges nor evidence of fire in the air accumulator.

"We believe this material is an excellent lubricant plus the fact that acting as a detergent the deposits normally found in compressor auxiliaries and valves have been reduced or eliminated."

These results are typical of what you can expect from Celanese Cellulubes. They have been developed to meet the pressing need for fire-resistant lubricants which virtually eliminate the problem of carbon deposits.

Celanese Cellulubes are available in 6 controlled viscosities: 90, 150, 220, 300, 550, 1000, S.U.S. @ 100° F. These straight phosphate esters provide excellent lubricity, are non-corrosive and non-reactive.

Celanese Cellulubes open new areas for in-plant protection against fire and explosion. Evaluate them in your own operation. Use coupon to request samples and technical data.

Celanese®
Cellulube®

Celanese
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CELANESE CELLULUBES

Ⓑ NYLOK®

FASTENS, SEALS, and LOCKS IN ONE FOOLPROOF OPERATION

WITHOUT SEALANTS

Ⓑ NYLOK fasteners are sure protection against gasoline, oil, air, and alcohol leaks. Stay locked in ANY depth...need not be fully seated...won't vibrate loose.

Permanent insert of tough, resilient nylon is readily adapted to any Ⓑ threaded fastener. Won't shrink, dry, age, or turn brittle. Unaffected by temperatures to 250° F...cannot damage threads or seating surfaces.

Ⓑ NYLOK fasteners can be reused time after time. Nylon insert regains original shape after using...retains original ability to adapt, lock, and seal to any thread.

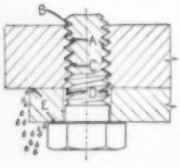
ELIMINATES

- costly locking devices
- double inventory
- lost time in application
- gummed-up threads that prevent reuse
- premature drying of fastener sealants

ASSURES

- instant sealing
- positive locking
- fast assembly... power driving
- smooth torque
- easy hopper feed

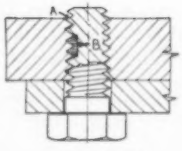
HOW NYLOK WORKS



STANDARD BOLT

← As bolt tightens, metal-to-metal union of LOAD BEARING faces is made at (A). But, fluid entering at (B) flows downward on NON-LOAD-BEARING faces, leaking out at (D) and (E).

Lateral thrust of NYLOK pellet (B) → presses both LOAD-BEARING and NON-LOAD-BEARING faces tightly together. Fluid entering at (A) is stopped from further flow by NYLOK insert (B).



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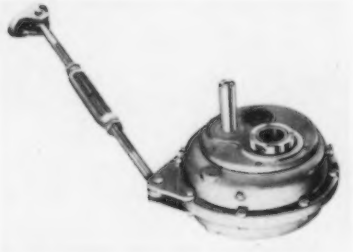
SELF-LOCKING SELF-SEALING Ⓑ **NYLOK® FASTENERS**

quired. A standard ⅜-in. round, cold-rolled steel rod fits each molded piece. All three current ratings can be assembled into one mounting strip. Open-type terminals and pan head screws that have captive wire clamps simplify wiring. **Gemco Electric Co., 25685 W. Eight Mile Rd., Detroit 40.**

Circle 17, inside back cover



Shaft-mounted gear reducer . . .

eliminates motor bases, rails, supporting structures and flexible couplings. Also eliminates alignment problems and makes possible infinite speed ratios through the use of variable-speed pulleys or by changing sheaves, sprockets or prime-mover speed. Available from stock are 18 models. Single-reduction types are 4.5:1 speed ratio, with 98% efficiency; double-reduction types are 14.7:1 speed ratio with 96% efficiency. Ratings range from fractional to 120 hp; output speeds from 8 to 425 rpm. Hollow-shaft bores range from 1⅛ in. to 5⅛ in., with bushing to accommodate undersize driven shafts. **Lovejoy Flexible Coupling Co., 4856 W. Lake St., Chicago 44.**

Circle 18, inside back cover

Digital strain-gage indicator . . .

accepts inputs from resistance-type transducers via a null balance servo, and converts these analog signals to digital readout in true units of measurement. Will also accept inputs from resistance bulb thermometers. Panel permits adjustment of controls to accommodate full or half bridge transducers with one, two or four active legs and to select proper polarity. Other controls regulate amplifier gain and balance and permit transducer calibration

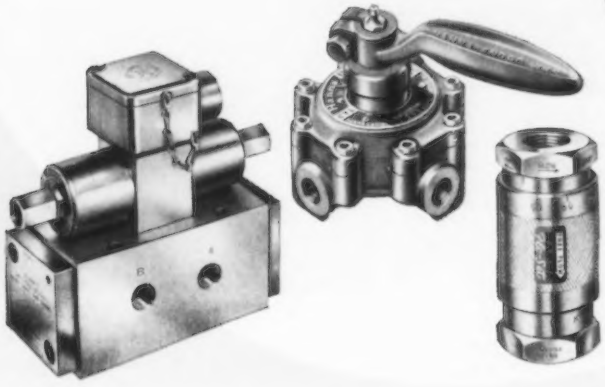
(Continued on page 107)

HANNA CYLINDERS

There is a complete line of Hanna Cylinders to suit all requirements of size and mounting . . . in capacities up to 250 psi for low pressure air or hydraulic operation, and up to 1500 psi hydraulic.

. . . finest combination for Dependable Fluid Power and Reliable Controls

HANNA VALVES



Designed to assure most efficient control, there are many types and sizes of Hanna Valves available for hand, foot and electric operation, for automatic, remote and speed controls.

It may not take over half a century to design and build a superior line of cylinders and valves . . . but the experience a company compounds in that time surely helps. Hanna has that background.

What does it mean to You, today—in terms of cylinders and control valves? — Basically these important things:

- Products designed and manufactured to the very highest standards of performance . . . not built down to a price—although they are competitive.
- A line so complete that you can specify a "standard" Hanna cylinder or valve to suit your "special" jobs.
- A plant engineering staff that backs a nationwide regional engineering-sales organization to help you quickly solve difficult problems—and to follow through on all your "needed now" requirements. Many Hanna Representatives stock the standard sizes and types of Hanna Products—the Hanna Plant, of course, does, too.

Whether you need cylinders and controls for equipment that is for resale, or for your own plant use . . . call or write your Hanna Representative (see classified telephone directory or Thomas' Register) or write us direct.

Hanna Engineering Works

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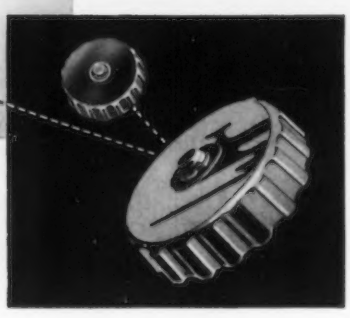
Put your finger on

IMPORTANT COST REDUCTIONS

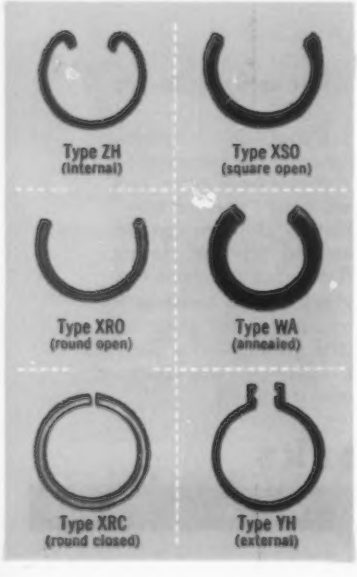
For Controls, Meters and Miniature Instruments

NATIONAL Retaining Rings conserve valuable space in portable equipment, pocket radios, hearing aids, controls, meters, instruments and miniature assemblies. Weight savings and reduction of manufacturing costs are added advantages.

Save time and materials ...and improve your products with...



NATIONAL RETAINING RINGS



Simplify design by specifying NATIONAL Retaining Rings on shafts and housings. These dependable rings save material, weight and assembly time wherever shoulders or collars are required. Grooving smaller diameters for retaining rings avoids cutting down larger diameter material to form shoulders and collars . . . saves costly machining, speeds assembly. NATIONAL Retaining Rings are service-proven on all types of equipment from heavy machinery to miniature assemblies. Ask for all the cost-saving facts, today!

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TRADE MARK

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By using extruded or mill-rolled shapes and flash butt-welding, American Welding can frequently help customers slash production costs of their circular products over other methods of manufacture. Savings in expensive metals are substantial, plus sizable reduction in machining time. And where some of the more difficult metals to weld — such as titanium, aluminum, zirconium, stainless and heat-resistant alloys — are required, American Welding has the special knowledge and equipment to do those difficult jobs to your specifications.

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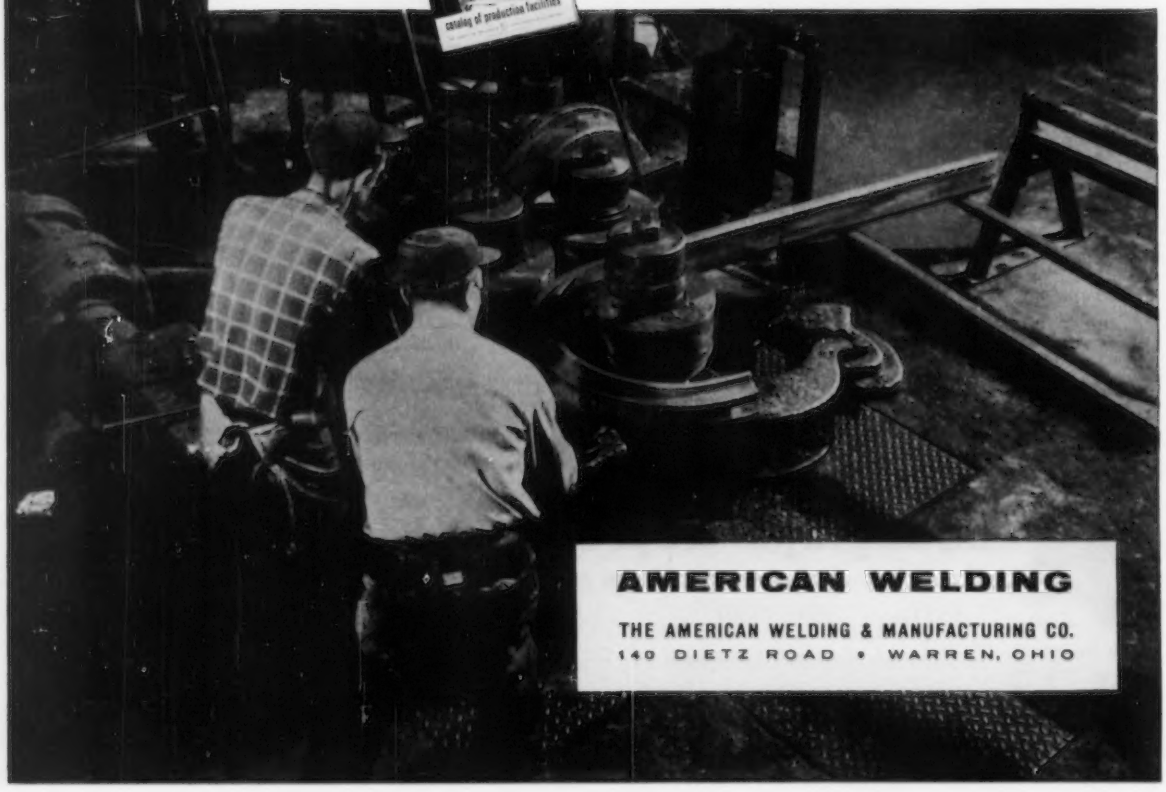
NEW PRODUCTS CATALOG AVAILABLE. Write today for 20-page catalog illustrating the many types of circular products American Welding can form, weld and machine for you.



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THE AMERICAN WELDING & MANUFACTURING CO.
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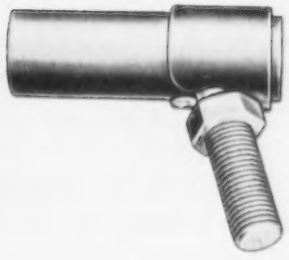
with built-in resistors of various ranges. A choice of visual or automatic digital readout is available to indicate and record the measured values on printers, electric typewriters, paper-tape perforators and IBM punch-card devices. The strain-gage dc power supply does not require regulation because the symbol for voltage across the bridge does not enter into circuit equations. **Datran Electronics, 3615 Aviation Blvd., Manhattan Beach, Calif.**

Circle 19, inside back cover

Manual reset solenoid valve . . .

allows unrestricted straight-through flow with an equivalent orifice of 0.250 in. dia and 3.8 in. tube size. Available in pressures to 4500 psi. Operates within a temperature range of −300 to 300 F. Approximately 2¼ amp momentary electrical surge is sufficient to actuate. A 24-v dc solenoid is furnished with the standard unit when electrical specs are optional. Unit weighs about 0.8 lb, unpotted. Can be normally open or normally closed and may be used for most hydraulic, pneumatic or cryogenic applications. **Pneu-Hydro Valve Corp., 364 Glenwood Ave., East Orange, N. J.**

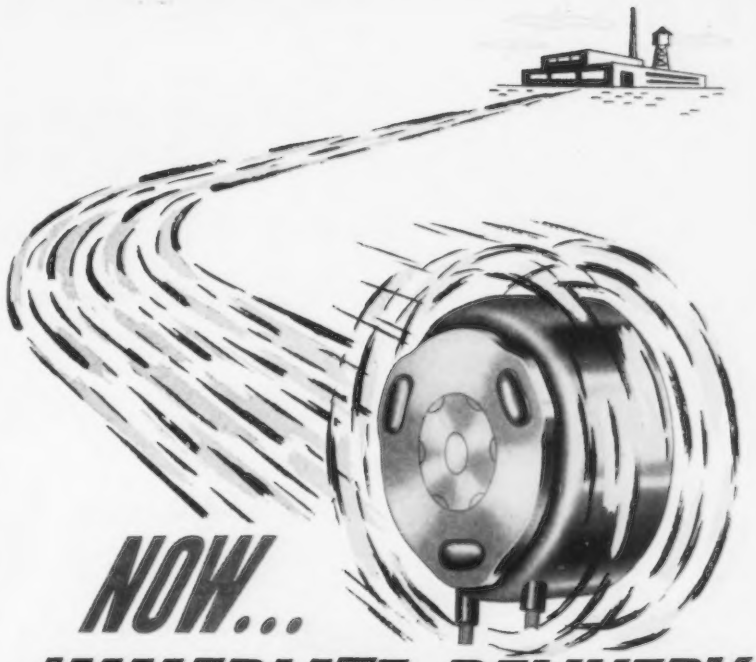
Circle 20, inside back cover



Heavy-duty ball joint . . .

is interchangeable with other SAE designs, yet has a 29% larger neck section with greater tensile strength. It permits a full 32° swing in all directions. A heat-treated, cadmium-plated spring-steel re-

(Continued on page 109)



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SOLENOIDS!

The following popular models of LEDEX Rotary Solenoids will be shipped the same day or the day after receipt of order . . . in quantities up to 9 of each model.

MODELS AVAILABLE WITH . . .

Three tapped holes in armature plate and scroll type return spring . . . or

shaft extension armature end, dust cover and scroll type return spring

. . . or shaft extension base end, dust cover and scroll type return spring

MODEL NUMBER	ROTATION R OR L	TORQUE VALUES POUND INCHES
BD1E	25°	.34
	45°	.10
BD2E	25°	.54
	45°	.24
BD3E	25°	1.18
	45°	.68
	67½°	.28
BD4E	25°	2.92
	45°	1.22
	95°	.32
BD5S	25°	7.05
	45°	3.15
	95°	.60

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contains complete engineering data on all models available for immediate delivery

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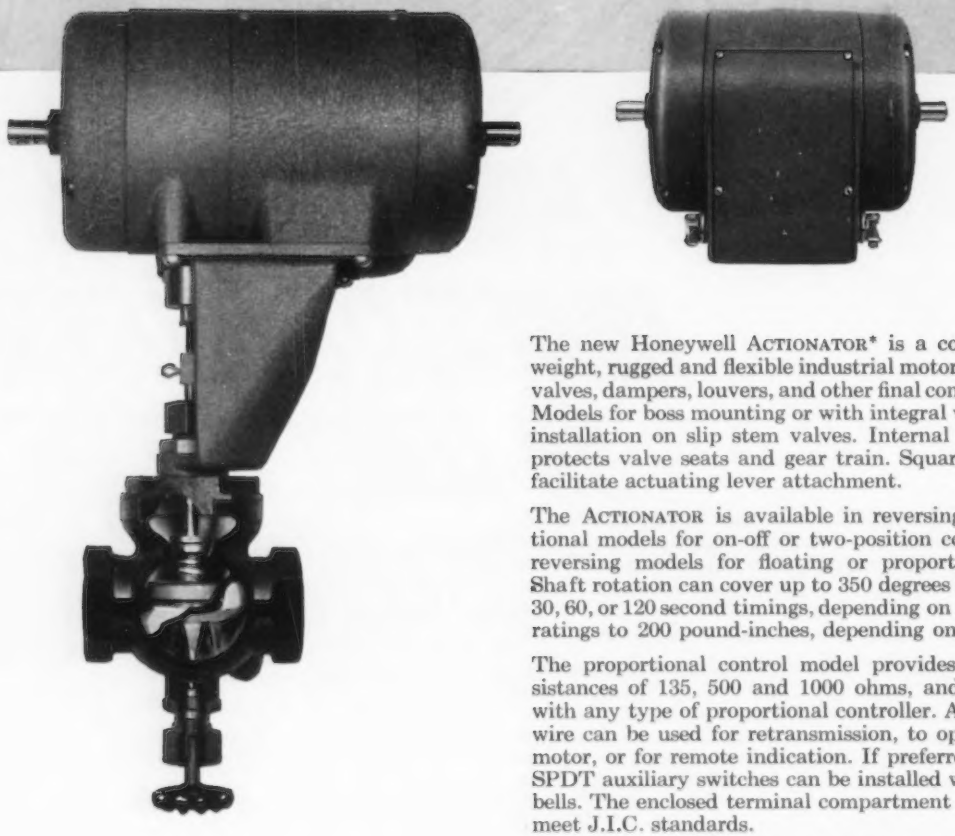
IN CANADA: Marsland Engineering Ltd., Kitchener, Ontario
IN EUROPE: NSF Ltd., 31-32 Alfred Place, London, England
NSF, GmbH, Further Strasse 101a, Nurnberg, Germany

NEW ACTIONATOR*

heavy duty electric motor for operating valves, dampers, louvers



The new Honeywell ACTIONATOR* is a compact, lightweight, rugged and flexible industrial motor for operating valves, dampers, louvers, and other final control elements. Models for boss mounting or with integral valve yoke for installation on slip stem valves. Internal strain release protects valve seats and gear train. Squared shaft ends facilitate actuating lever attachment.

The ACTIONATOR is available in reversing or unidirectional models for on-off or two-position control, and in reversing models for floating or proportional control. Shaft rotation can cover up to 350 degrees in 7½, 10, 15, 30, 60, or 120 second timings, depending on model; torque ratings to 200 pound-inches, depending on motor speed.

The proportional control model provides slidewire resistances of 135, 500 and 1000 ohms, and can be used with any type of proportional controller. A second slidewire can be used for retransmission, to operate another motor, or for remote indication. If preferred, SPST and SPDT auxiliary switches can be installed within the end bells. The enclosed terminal compartment is designed to meet J.I.C. standards.

Specially designed MICRO SWITCH switches allow the ACTIONATOR to be used where ambient temperatures range from 25 to 150 F.

For complete information and specifications on the new ACTIONATOR, call the nearest Honeywell office, or write (send coupon) to:

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Phila. 44, Pa.

Industrial Division
MINNEAPOLIS-HONEYWELL REGULATOR CO.
Wayne and Windrim Avenues, Philadelphia 44, Pa.

☐ Please send me additional information on the ACTIONATOR.

☐ I'd like a Honeywell sales engineer to discuss applications of the ACTIONATOR in my plant.

Name_____

Title_____

Company_____

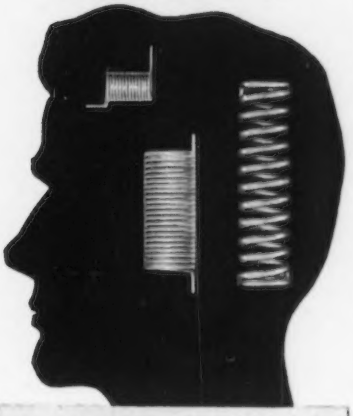
Address_____

*Tradename Minneapolis-Honeywell Regulator Co.

MINNEAPOLIS **Honeywell**

First in Controls

SPRINGS ON YOUR MIND?



• Your next thought should be of the Spring Engineers at John Chatillon & Sons. Send them your blueprints and specifications for study and recommendation.

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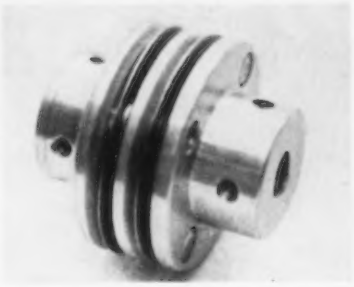
Manufacturers of Precision Springs and Force Measuring Instruments Since 1835

taining sleeve gives ball cavity greater protection against abrasive particles. Grommet rides freely on steel retaining sleeve without restricting motion of case-hardened steel ball stud. Unit makes possible a multiple ball-joint-rod control assembly with ball joints installed at any point along length of rod. **Superior Ball Joint Corp., 8908 Trier Rd., Ft. Wayne, Ind.**

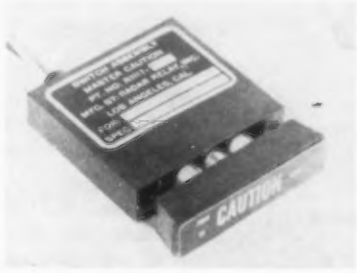
Circle 21, inside back cover



Miniature flexible couplings . . .

of two types are made in two sizes for each type, ranging from $\frac{1}{32}$ in. to $1\frac{7}{8}$ in. OD for shaft dia from $\frac{1}{8}$ to $\frac{1}{4}$ in. Rated to transmit from 30 to 45 in-lb torque at high speeds. Couplings are torsionally rigid, without backlash, and absorb angular misalignment to $7\frac{1}{2}°$, lateral misalignment to 0.015 in., and axial movement to 0.060 in. in a single unit. The all-metal unit has no moving parts and requires no lubrication. Immediate delivery. **Dial Products Co., 9 Ave. E, Bayonne, N. J.**

Circle 22, inside back cover



Switch assembly . . .

has a lighted bar containing any desired warning nomenclature. Unit is lighted by three AN3140-327 lamps in parallel that provide an average light intensity of more than 250 lamberts, enough to make assembly visible in direct sunlight. Pressing the lighted strip actuates a switch inside the unit that can be used for resetting an annunciator system or for any other control. Unit is about 0.47 in. x 2.13 in. x 2.6 in. Can be installed with 6-32

(Continued on page 112)

Solve Your HOT PROBLEMS with VULCAN VERSATILITY

IN FINNED STRIP HEATERS

Vulcan Finned Strip Elements provide ideal heat for blower type electric unit heaters, duct heating, unit convection heating, as oven or space heaters in dryers, pump rooms, etc.

You have a wide choice of standard sizes — from 10½" to 42½"; wattage from 500 to 3250 or higher; voltage — 120, 240 or higher; steel, for sheath temperatures to 750°F; Chromalloy for temperatures to 1250°F; rugged non-oxidizing terminal posts.

When your hot problem calls for unusual specifications, you get a speedy solution through *Vulcan Versatility* in engineering and production. Standard or special, Vulcan is ready to supply your complete needs in low-cost efficient heating units — finned, cartridge, strip, tubular, immersion, band and ring heaters. Send coupon for catalog and prices.

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Cartridge • Strip • Tubular • Immersion Electric Heaters • Soldering and Branding Irons Solder and Glue Pots

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Please send me your catalog and price information on Vulcan Electric Heaters. I am especially interested in (check)

☐ Tubular ☐ Finned
☐ Immersion ☐ Cartridge
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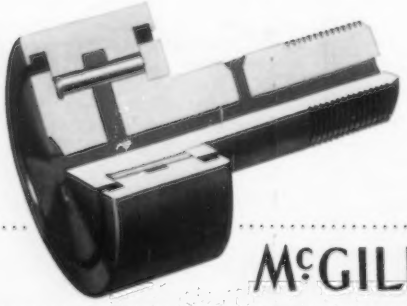
only McGILL® sealed *CAMROL*® cam followers give you . . .

effective sealing

prelubrication

high radial and shock capacity

in a full range of sizes



Effective sealing of the CAMROL cam follower against moisture, dirt, chips, etc. guarantees longer service life . . . reduces maintenance. This sealed construction retains lubricant and eliminates need for frequent relubrication, so often undesirable in cam action, guide support and track roller applications.

Special seals are built in at stud and flange ends. A black oxide finish on all exposed surfaces offers outside corrosion resistance. The channeled reservoir above the rollers in the outer raceway bore helps store reserve lubricant, sufficient in most cases for lifetime service. Relubrication is possible through convenient oil holes. The new SCF sealed CAMROL cam followers interchange with proven standard CAMROL cam followers. Standard stock with roll diameters up to 4″ are available for both stud and shaft mounting.

For maximum bearing life where contamination is a problem, specify sealed CAMROL cam followers. Ask your McGill representative or our engineering department for recommendations.

Write for Catalog No. 52-A

McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

MOLY NEWS

CLIMAX MOLYBDENUM COMPANY, 500 FIFTH AVENUE, NEW YORK 36, N. Y.

Super-Strength Structural Steels Boost Minimum Yield Strengths to 150,000 psi.

Seven steel companies in the U. S. are now producing a group of "Super-Strength Structural Steels" with considerably higher yield strengths than the well-known "High-Strength Low-Alloy" steels.

These Super-Strength steels offer minimum yield strengths ranging from 55,000 to 150,000 psi. And they have other useful properties, depending on composition, including strength at moderate temperatures, toughness at low temperatures, and good wear resistance. Almost all of these steels contain molybdenum as an essential element.

The search for steels with greater yield strengths has gone on for many years. Before about 1930, carbon steels with a yield point of roughly 30,000 psi were standard for almost all structural purposes. Then came the development of "High-Strength Low-Alloy" steels. They boosted minimum yields into the 50,000 psi range.

Now, the newer Super-Strength Structural Steels are being welcomed by designers, who see in them a way to solve one of their major problems — to minimize weight and size while retaining quality and reliability.

. . . For more information on these steels, including their trade names and compositions, circle number 1 on the coupon.

Moly's High Hot Strength Shows Promise for Jets and Rockets

Molybdenum-base alloys were described at the 1955 American Rocket Society annual meeting as having the greatest promise for true high-temperature operation.

Missile and powerplant designers are interested in moly mainly for its high temperature strength. Molybdenum-base alloys have been developed with higher useful strength at temperatures over 1600 F than any other presently known metallic material.

The jet propulsion field — including guided missiles and aircraft powered by rocket, ramjet, and turbojet engines — covers a tremendous variety of requirements and service conditions in respect to temperature, atmosphere, amount and type of stress, vibration, thermal shock, and prospective life. Molybdenum's properties make it a logical choice in many cases because it has:

1. High creep and rupture strength.
2. High tensile strength at high temperatures.
3. High modulus of elasticity.
4. A combination of high thermal conductivity, low specific heat, and low expansivity, which minimizes nonuniform temperature distribution and makes molybdenum insensitive to thermal shock.
5. High resistance to erosion by hot gases.
6. High melting point.

It seems safe to conclude that molybdenum-base alloys will become important structural materials in the jet propulsion field. And they will become essential for many parts operating at temperatures in excess of 1600 F.

. . . from "Molybdenum for High strength at High Temperatures," by R. Freeman and J. Briggs, JET PROPULSION, *February, 1957.*

For a copy of the complete article, circle number 2 on the coupon.

Moly Adds Strength and Corrosion Resistance to Titanium

Commercially pure titanium is fairly strong and highly corrosion-resistant. Alloying it, however, substantially increases these useful properties.

Molybdenum may prove to be one of the most useful of the alloying elements for titanium. Studies at Armour Research Foundation, for example, show that when molybdenum is used instead of vanadium, creep properties are greatly improved. At 1020 F, a stress of approximately 20,000 psi produces a creep rate of 10^{-4} in. per in. per hr in Ti-6 Al and Ti-6 Al-4 V, whereas 40,000 psi is required to produce the same creep rate in a Ti-7 Al-3 Mo alloy.

In summary, new alloy development is opening the way for titanium's extensive use in jet engines and air frames. Ti-Al-Mo alloys, for example, give better elevated temperature properties than the Ti-6 Al-4 V alloy now most widely used. And the alloy containing 7% Al and 3% Mo appears particularly promising.

Another Ti-Mo alloy contains 30 to 40% Mo. This alloy is claimed to resist boiling 40% sulphuric acid and boiling 20% hydrochloric acid as well as platinum, tantalum or gold. Such a retained beta alloy is weldable and could be fabricated into sheet. These corrosion-resistant characteristics would add to the value of all-beta Ti-Mo alloys.

. . . from "Molybdenum as an Alloy Addition for Titanium," by Harold Margolin, METAL PROGRESS, *February, 1957.*

For a copy of the complete article, circle number 3 on the coupon.

Moly Goes to Sea In A Sewer

Cast iron joint ring in pipe, before lowering into position. Joint rings were made by Alhambra Foundry Co., Ltd. and the concrete pipes poured by American Pipe and Construction Co.

Positioning 64 ton reinforced concrete sewer pipe sections puts quite a strain on the cast iron joint rings used to join them. Especially when the job is done under water at depths up to 210 feet.

Joint rings must be strong enough to withstand stresses developed when the pipe is drawn together, plus sufficient impact resistance to withstand handling and placement.

Those are good reasons why the County Sanitation District No. 2 of Los Angeles County specifies ASTM A 48, class 40 iron for the rings. In addition to the required 40,000 psi, tensile strength, and 2600 lb transverse strength minimum, (on a 1.2 in. test bar), the bar must be capable of deflecting at least 0.20 in. and the iron must contain at least 0.40% Cr, 0.60% Cu and 0.35% Mo.

Examination of pipe lengths after six years' service showed them in excellent condition. Equally good performance is expected from the most recent installations which extend some 8000 feet into the Pacific Ocean, and are believed to be among the largest in the country.

. . . For more information on the contribution of moly to toughness and shock resistance of cast iron, circle number 4 on the coupon.

Climax Molybdenum Company, Dept. 61,
500 Fifth Avenue, New York 36, N. Y.

I'd like more information on:
1 2 3 4

Name_____

Address_____

City_____

New G-E Indicator Lamp "lives" 10,000 hours ... resists shock and vibration ... needs no transformer

The light output of the new General Electric Glow Lamp, NE-79 is easily sufficient to illuminate the legend in a cover glass or lenses in a diversified array of indicators. Made for use on 105-125 volt circuits, in series with a 1 watt 7500 ohm resistor, no transformer is needed. Since the bulb is only 7/8" in diameter it fits pilot assemblies which go into a 1" mounting hole.

The NE-79 has inherent resistance to both shock and vibration and, since it is equipped with a double contact bayonet base, it cannot shake loose in the socket. For further information on the NE-79 glow lamp write to General Electric Company, Miniature Lamp Department PE-18, Nela Park, Cleveland 12, Ohio.

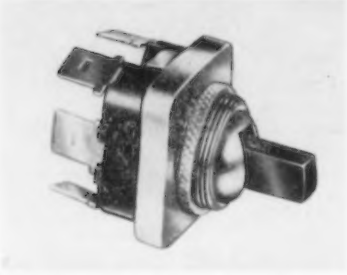
Other General Electric Glow Lamps have electrical characteristics that let them serve as relaxation oscillator, leakage indicators, switches, voltage regulators, or voltage indicators.

Progress Is Our Most Important Product

GENERAL ELECTRIC

screws. Locking provisions are selfcontained. Qualified under extremes of vibration, shock, high and low temperatures and a life of 50,000 operations. Nomenclature is available in red or amber with opaque or lighted background. **Radar Relay, Inc., 2120 Pontius St., Los Angeles 25.**

Circle 23, inside back cover



Flush-mounting toggle switch . . .

provides single-throw two-position, double-throw two-position or double-throw three-position On-Off-On operation. Switch can be furnished with long or short phenolic toggles, black or colored; or bat-type or barrel-type metal handles to meet customer specifications. Electrical rating is 15 amp, 125 v; 7½ amp, 250 v ac. Also, 2 or 6 amp, 125 v ac or 20 amp, 250 v ac. UL-inspected Binding-head screws, solder-type or quick-disconnect terminals are available. **Arkles Switch Corp., 51 Water St., Watertown 72, Mass.**

Circle 24, inside back cover

Counter-height enclosures . . .

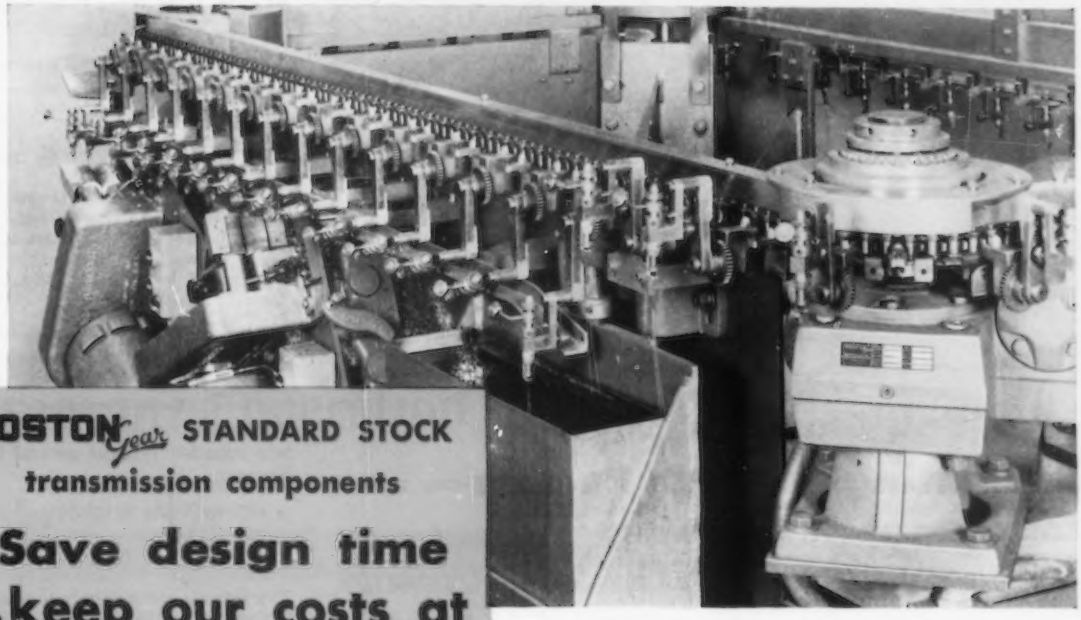
for control equipment, where operators are required to stand or to be on the move. Can be used individually or can be bolted together side-to-side, back-to-back or joined to the front or back of other cabinet frames. Counters are 18½ or 22 in. deep x 36½ in. high without casters; 37 in. high with casters. **Elgin Metalformers Corp., 630 Congdon Ave., Elgin, Ill.**

Circle 25, inside back cover

Snap-acting switch . . .

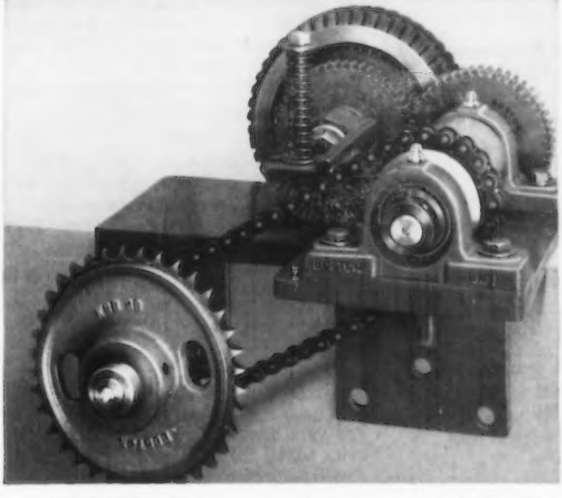
is designed for high-speed, low-force, momentary-contact switching of electrical circuits. Subminiature switch provides DPDT circuit control with application of about 2-oz force to pushbutton. Operating plunger, keyed to prevent rotation, allows total movement of ¼ in. Pushbutton can be black, red, blue, yellow or green and

(Continued on page 117)



BOSTON Gear STANDARD STOCK transmission components

"Save design time ...keep our costs at lowest level"



THIS SPECIAL MACHINE, *(above)* is built by the Eraser Co., Inc., for automatically stripping and soldering fuse plug lead wires. It requires the highest standards of precision and performance in all components. Assembly includes BOSTON gears, rack, pillow blocks, pulleys, sheaves, and bushings, — also the BOSTON Ratiomotor shown at the right. Manufacturer says — "In designing special machines, we use standard stock parts wherever possible. They save design time and keep our manufacturing costs at the lowest possible level."

THIS DRIVE for a rotary nylon bristle brush *(left)* is a component of an over-feed device for tentering frames made by Marshall & Williams Corp. This manufacturer of textile finishing equipment knows the many advantages of "Design around BOSTON Gear". The standard gears *(laminated phenolic)*, sprockets, chain, and pillow blocks used are all supplied from local Distributor's stock.

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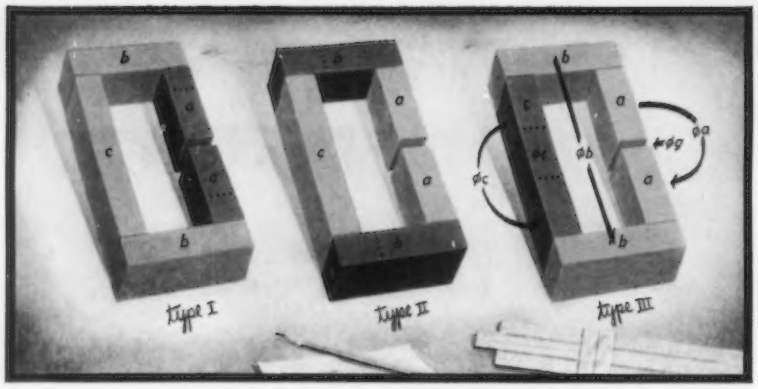

How You Can Save Time Estimating Leakage Factors for Magnetic Circuits

Computing even approximate values for leakage flux in magnetic circuits is a time consuming job. The research department of Indiana Steel recently undertook a series of studies, supported by the U.S. Air Force, to simplify these computations. Dr. R. K. Tenzer reported the results of this work, which reduce the time in computing leakage flux up to 90% by diminishing the number of mathematical operations necessary.

The investigations were done on circuits with permanent magnets; the results were also found applicable to unsaturated electromagnetic circuits when the coil-covered parts were treated as permanent magnet parts.

After checking values obtained by this method with actual measured values for many Type I, II, and III magnetic circuits, deviations were found to be less than ± 10%.

Leakage Flux, Leakage Factor

Because of magnetic leakage, only a part of the total flux through the neutral zone of the permanent magnet is found in the air gap. The difference between these two values is known as leakage flux. Mathematically this is:

$$\phi_L = \phi_t - \phi_g. \tag{1}$$

In practical design, leakage is best considered as a factor stated thus:

$$\sigma = \frac{\phi_t}{\phi_g} = 1 + \frac{\phi_L}{\phi_g}. \tag{2}$$

For simplification, the flux can be assumed to follow three basic, probable paths: ϕ_a between parts a, ϕ_b between parts b, and ϕ_c along part c. The equation above then becomes:

$$\sigma = 1 + \frac{\phi_a + \phi_b + \phi_c}{\phi_g}. \tag{3}$$

With $\phi = mmf \times P$, this formula can be written:

$$\sigma = 1 + \frac{1}{P_g}\left(\frac{mmf_a}{mmf_g}P_a + \frac{mmf_b}{mmf_g}P_b + \frac{mmf_c}{mmf_g}P_c\right). \tag{4}$$

Letting the *mmf* ratios be denoted by K,

$$\sigma = 1 + \frac{1}{P_g}\left(K_aP_a + K_bP_b + K_cP_c\right). \tag{5}$$

This becomes the basic equation for numerical calculations of leakage factors after introducing simple expressions for leakage permeances and mmf ratios.

Simplified Leakage Permeances

The following formulas have been found satisfactory for leakage permeances between soft steel parts:

$$P_a = 1.7 \times U_a \times \frac{a}{a + L_g} \text{ where } U \text{ is} \tag{6}$$

cross-section perimeter;

$$P_b = 1.4 \times b \times \sqrt{\frac{U_b}{c} + .25} \tag{7}$$

where U_b/c is greater than .25 and less than 4. The total length of part b is used.

Since permanent magnets have a neutral zone which does not contribute to leakage, the value of 2/3 of the magnet's total length is used when computing leakage permeances—this is the effective length a' and b' to compute P'; thus the two equations above become:

$$P'_a = 1.7\ U_a \frac{.67a}{.67a + L_g} \tag{6a}$$

and

$$P'_b = 1.4 \times .67b\sqrt{\frac{U_b}{c} + .25} = .67\ P_b. \tag{7a}$$

When part c consists of a permanent magnet (Type III) its permeance can be calculated as:

$$P_c = .5\ U_c. \tag{8}$$

The permeance of the air gap itself is

$$P_g = A_g/L_g. \tag{9}$$

Simplified MMF Ratios

Simplifying the *mmf* ratios is done by neglecting the reluctance in *soft steel parts;* so

$$mmf_a = mmf_b = mmf_g \text{ or } K_a = K_b = 1$$
$$(mmf_c = 0 \text{ so } K_c = 0). \tag{10}$$

Since the *mmf along permanent magnet parts* is not constant, integral values ($\overline{mmf}$) are used. Experiments showed that 2/3 of the mmf_g was the effective *mmf* for leakage flux between permanent magnet parts; thus

$$\overline{mmf_a} = \overline{mmf_b} = \overline{mmf_c} = 2/3\ mmf_g$$

or

$$K_a = K_b = K_c = 2/3. \tag{11}$$

Basic Formulas

By inserting the permeances for soft steel into equation (5), the general formula becomes:

$$\sigma = 1 + \frac{L_g}{A_g}\left(K_a \times 1.7\ U_a \frac{a}{a + L_g} + K_b \times 1.4\ b\sqrt{\frac{U_b}{c} + .25} + K_c \times .5\ U_c\right). \tag{12}$$

This formula contains only constants and dimensions; and by the two following rules this can be modified into the three basic equations for the Type I, Type II, and Type III circuits.

Rules: (1) For leakage flux paths between soft steel parts, use total lengths and constant K of 1. (2) For leakage flux paths between permanent magnet parts, use 2/3 of lengths and K of .67.

The following provide the leakage factors for the three types of circuits:

Type I:

$$\sigma = 1 + \frac{L_g}{A_g} \times .67 \times 1.7\ U_a \frac{.67a}{.67a + L_g}$$

Type II:

$$\sigma = 1 + \frac{L_g}{A_g}\left(1.7\ U_a \frac{a}{a + L_g} + .67 \times .67 \times 1.4b\sqrt{\frac{U_b}{c} + .25}\right)$$

Type III:

$$\sigma = 1 + \frac{L_g}{A_g}\left(1.7\ U_a \frac{a}{a + L_g} + 1.4b\sqrt{\frac{U_b}{c} + .25 + .67 \times .5\ U_c}\right)$$

For variations on these basic formulas, write today for the April-June issue of *Applied Magnetics* which also shows examples of the formulas in use.

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***Progress** in designing air systems:*

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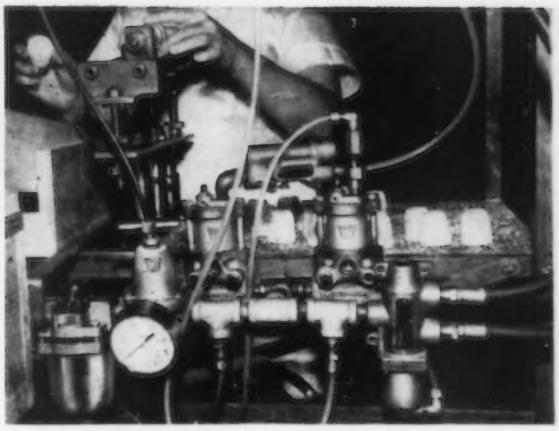
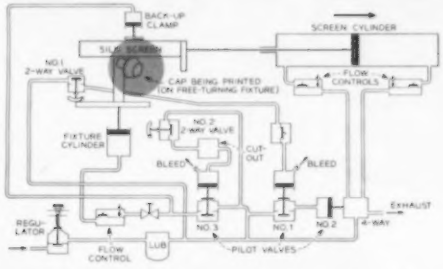
PROBLEM: To print bottle caps accurately at high speed.

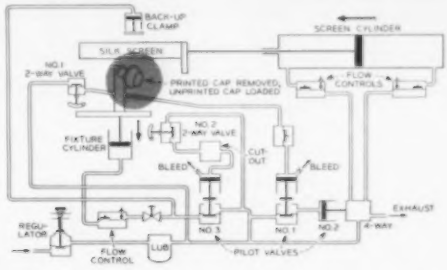


PROVED IN OPERATION: Prominent silk screen printer puts Schrader products to work at a profit.

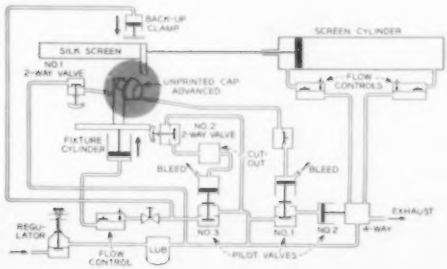
SOLUTION: Adapt Schrader Air Products to silk screen printer.



1 Fixture holding plastic cap on freely rotating fixture is held up against silk screen by Schrader cylinder. Another Schrader cylinder pushes screen sideways over the freely rotating cap, imparting the printed message.



2 Fixture with printed cap moves down, back-up clamp retracts and screen cylinder returns to initial position. Operator removes printed cap and loads another unimprinted cap.



3 Schrader cylinder advances fixture upward loaded with unimprinted plastic cap. Back-up clamp starts downward toward silk screen. And cycle starts all over again.

This is but one precision operation of the limitless operations which can be controlled *fast, economically* and *accurately* by Schrader Air Products. The hundreds of different units in Schrader's complete line can be employed alone or in combination to perform stamping, programming, forming, measuring, squeezing—other jobs too! And wherever air is used, economy is basic.

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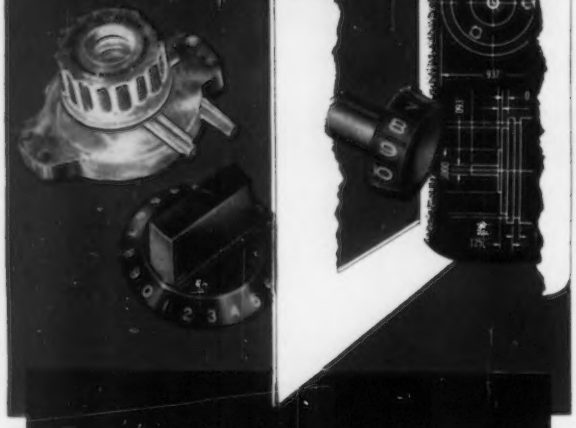

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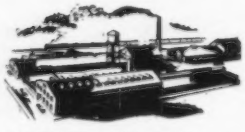

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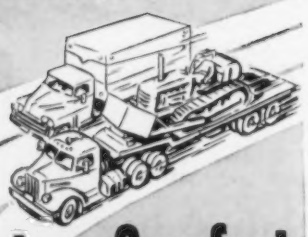

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Circle 26, inside back cover

Relays with dust covers . . .

that are removable mount on customer's strip, panel or chassis. To support cover, a rigid steel frame is attached to relay and mounting. Cover fits over frame and is secured with a single screw. Dust cover is available with Class 22 ac or dc-operated relays in contact combinations to 6PDT, Class 22T bifurcated contact relays, Class 22S time-delay relays, Class 22R and Class 22D power relays. **Magnecraft Electric Co., 3350Y W. Grand Ave., Chicago 51.**

Circle 27, inside back cover

High-strength blind rivet . . .

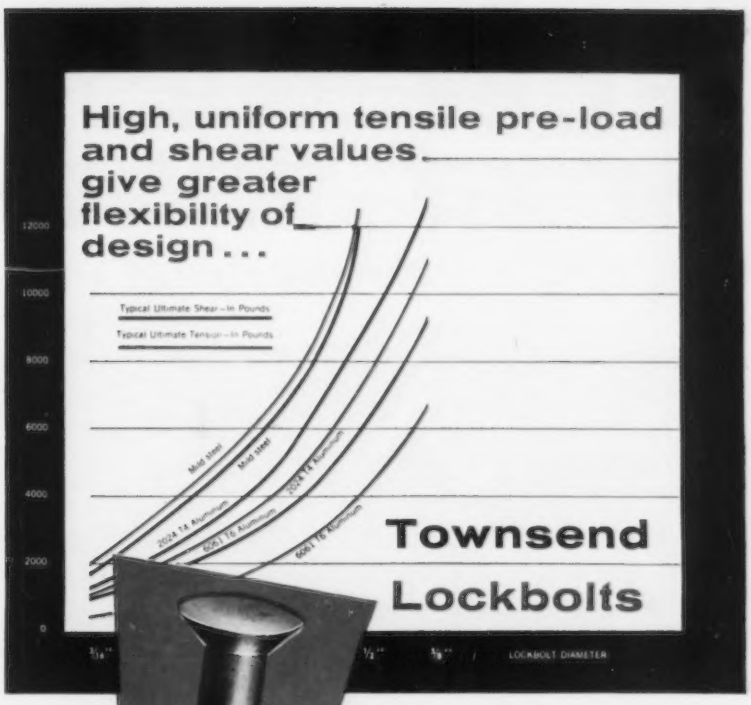
is suited to all types of light sheet metal application and is installed with standard pneumatic tooling. A swaged, positive mechanical lock insures pin retention. Available with ⅜-in. split-sleeve length and a 0.032 to 0.250-in. grip range or a ⅞-in. split-sleeve length and a 0.032 to 0.375-in. grip range. Both sizes have a 7.16-in. dia washer-type collar. The rivet is made of a steel sleeve-washer and a heat-treated steel pin, factory-assembled. Widespread gripping leaves, formed from split sleeve when installed, make hole size a noncritical assembly design consideration. **Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7.**

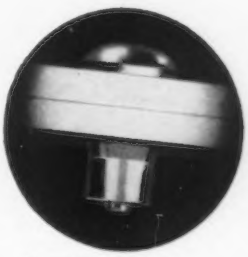
Circle 28, inside back cover

Wide-scale panel meters . . .

spanning 300° cover 15% more scale than 250° instruments. Response time and damping are said to be four to five times

(Continued on page 118)





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Circle 29, inside back cover

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Circle 30, inside back cover

Four-post drafting tables . . .

are secured with steel bolts and reinforced with steel. A three-receptacle electrical outlet with cord is mounted right in the frame. Drawers are heavy-gage steel with wood fronts. Wide reference drawer and tool drawer is equipped with tool tray,

(Continued on page 119)

lock and two keys. The pedestal drawing tables have hardwood bases finished in dark oak. Two steel bracing clamps assure rigidity and steel angle braces give balanced adjustment. Single handwheel sets the angle. Board height is adjusted by a handwheel, too. Seven models with boards ranging from 24 x 30 in. to 43½ x 72 in. are offered. **Stacor Equipment Co., 295 Emmet St., Newark 5, N. J.**

Circle 31, inside back cover

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Circle 32, inside back cover

Hermetically sealed relay . . .

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Circle 33, inside back cover

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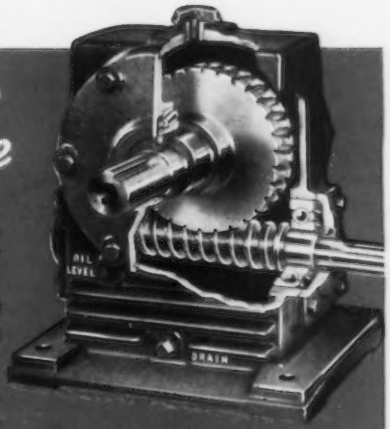

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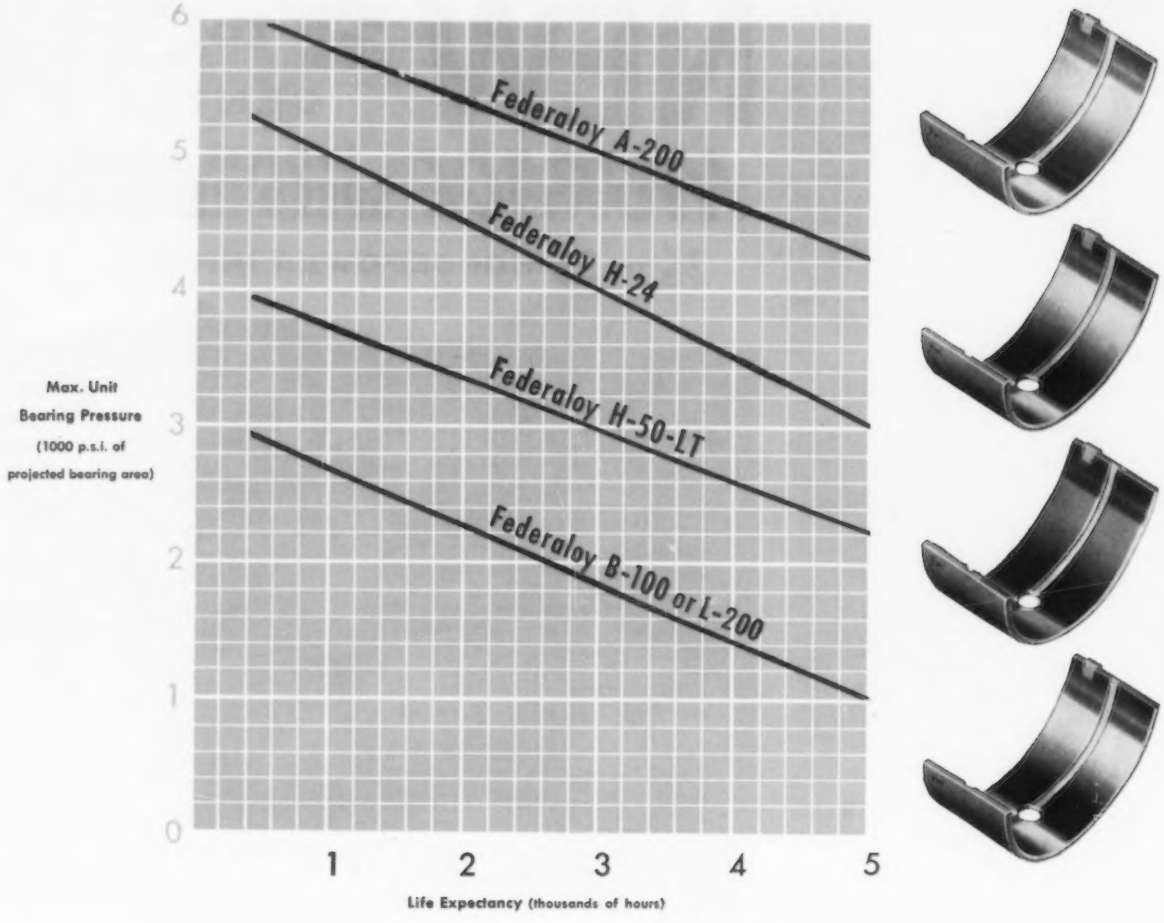

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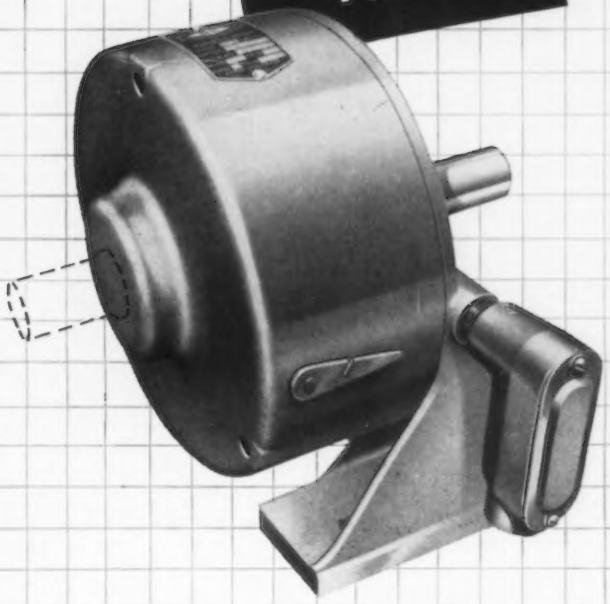

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Cutaway view of endbell mounting type

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Heinze new Blower-Heater Combination Units are ideal for warming and drying in such applications as hot food vending machines, photographic dryers, food warmers. Blower is designed for continuous operation. Heater can be thermostatically controlled through separate terminals.

Motor operates on 110 V, 60 cycles. Type DS delivers 55 cfm (free air) at 3000 rpm. Type YSS delivers 50 cfm (free air) at 1500 rpm. Heaters are available from 200 to 1000 watts, single phase. Coiled wire heating element is well insulated to protect outer wall. Choice of mountings includes outlet or inlet, flat strap, or "L" shaped brackets.

Send coupon for complete technical data.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.
Sub-Fractional Horsepower Motors and Blowers

HEINZE ELECTRIC COMPANY
685 Lawrence Street, Lowell, Mass.

Please send me literature and price information on Heinze Blower-Heater Combination Units.

Name & Title.....

Company.....

Street & No.....

City & State.....

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

SOLDERLESS WIRING DEVICES—Catalog, 8 pp. Describes and illustrates solderless terminals and connectors for crimping to wire. Data and sizes of various devices are included to aid selection Representative samples of ETC terminals and connectors are included with each catalog. Electrix Terminals & Connectors, Inc., 990 E. 67th St., Cleveland 3.

Circle 34, inside back cover

MASKING AIDS—Brochure M-18, 4 pp. Illustrates line of masking plugs, caps, corks, with dimension tables to simplify size selection. Also shows dispensers for pressure-sensitive tapes. By-Buk Co., 4314 W. Pico Blvd., Los Angeles 19.

Circle 35, inside back cover

THERMOSETTING LAMINATED SHEETS—Loose-leaf catalog, 12 pp. Included is a materials list for quick identification of each product by NEMA grade, resin and base and significant characteristics. Technical data sheets and price lists for epoxy-glass, epoxy-paper and cold-punching phenolic paper are in the catalog. Sheets on individual products are available for those who do not require the complete catalog. New England Laminates Co., Inc., 481 Canal St., Stamford, Conn.

Circle 36, inside back cover

INDUSTRIAL SOLENOIDS – Catalog 572, 6 pp. Gives illustrations, dimensional drawings and force characteristics on every industrial solenoid model, ac or dc, in line. Detroit Coil Co., 2435 Hilton Rd., Ferndale 20, Mich.

Circle 37, inside back cover

STEEL TUBING WEIGHTS—Booklet, 12 pp. A standard factor for converting round steel tubing weights to square or rectangular tubing is given in the booklet. Simplified instructions for determining weights are included. Data is applicable to welded or seamless steel tubing. Revere Copper and Brass, Inc., Rome Mfg. Co. Div., Box 111, Rome, N. Y.

Circle 38, inside back cover

ELECTROMAGNETIC RELAYS – Booklet, 132 pp. Papers presented at 5th National Conference on Electromagnetic Relays. Subjects covered include: low energy level circuits, dry circuits, contact loading, contact bounce, reliability, vibration testing, testing techniques, thermal relays, electromagnetic relays, miniaturization, missile applications. Potter & Brumfield, Inc., Princeton, Ind.

Circle 39, inside back cover

END FACE SEALS—Bulletin EF-100, 6 pp. Specifications and description of end face seals. Information is presented in table form. With dimensional drawings. Chicago Rawhide Mfg. Co., 2720 N. Greenview Ave., Chicago 14.

Circle 40, inside back cover

FILTERS AND STRAINERS – Catalog 58-100, 20 pp. Specs, performance characteristics and application data. Supplemented with diagrams, charts and illustrations. Thumb-indexed. Cuno Engineering Corp., South Vine St., Meriden, Conn.

Circle 41, inside back cover

HEAT EXCHANGERS—Bulletin 1.1K6, 8 pp. Specs of 46 sizes in one, two and four-pass designs. Modifications for special conditions are also included. Ross Heat Exchanger Div., American-Standard, Buffalo 5, N. Y.

Circle 42, inside back cover

DESIGNING WITH ALUMINUM – Booklet, 56 pp. Bound volume of advertisements that appear throughout the year on properties, applications, fabricating and finishing. Kaiser Aluminum & Chemical Sales, Inc., Dept. PD-1, 919 N. Michigan Ave., Chicago 11.

Circle 43, inside back cover

REPEAT CYCLE TIMERS – Bulletin AWH RC-301, 2 pp. Subminiature timers are described, charts on cycling times with outline and mounting dimensions, approximate weights, and tabulation of military specs are included. A. W. Haydon Co., Waterbury, Conn.

Circle 44, inside back cover

GLASS TUBING—Catalog 80-20. Lists tubing in a variety of shapes and in sizes from 0.003 to 6 in. ID. Bore dia are controlled to ± 0.0002 in. Discusses range of applications, materials, shapes. Fischer & Porter Co., 491 Jacksonville Rd., Hatboro, Penna.

Circle 45, inside back cover

SUPERPRESSURE ITEMS – Catalog 407, 125 pp. Lists standard and accessory high-pressure items for pressures to 100,-

(Continued on page 124)

Over $1,000,000 a year

saved with OILITE Precision Parts

This kit contains intricate parts used by a score of companies who save over $1,000,000 annually by specifying Oilite*!

These companies are typical of many manufacturers of appliances, machinery, automotive accessories, power tools and other products who enjoy the substantial cost reductions made possible by Amplex Powder Metallurgy.

You, too, can have a share in these savings. Chrysler-engineered Oilite Precision Parts can save you up to 55% or more when produced in volume. What's more, you'll find Oilite powder metal parts tough and long wearing. They're available in a large variety of metals and alloys to meet required properties.

Your local Oilite Engineer will be glad to provide complete information on any application. Furthermore, he will gladly survey all the parts you now buy for possible cost reductions *at no obligation*. Look for him in the Yellow Pages of your telephone directory under "Bearings — OILITE" or write to Dept. A-1.

TYPICAL PROPERTIES
OF STEEL OILITE*
PRECISION PARTS

(Grades)	A	AC	AH
Fatigue Strength (Psi) 10,000,000 reversals	24,000		
Ultimate Tensile Strength (Psi)	35,000	50,000	120,000
Compressive Strength (Psi) .001" permanent set	25,000	80,000	150,000
Elongation in 1", % minimum	10	5	1
Brinell Hardness	80	140	300
Shear Strength (Psi)	27,000	35,000	100,000

* Many other materials giving different properties available.

Engineers in the principal cities in US and Canada.

A CHRYSLER OILITE® PRODUCT

the most trusted name in powder metallurgy

SINCE 1929

AMPLEX DIVISION

CHRYSLER CORPORATION, DETROIT 31, MICHIGAN

BEARINGS • PRECISION PARTS • METAL FILTERS • FRICTION UNITS

® REGISTERED TRADEMARK • ONLY CHRYSLER MAKES OILITE.

NEW DEVELOPMENT FROM

Robertshaw-Fulton

a combination low-cost

Temperature Control and Switch

with FIXED SETTING

Especially suited for use in restaurant coffee warmers, egg washers, heaters for livestock water tanks and many other applications where an economically priced control for maintaining a fixed temperature is required. This new "EU" Control, made of stainless steel for durable service, is permanently calibrated for any required temperature specified. For example, it may be slightly over 100°F for milk warming equipment, or 375°F for use in deep fat fryers, or even higher for commercial or laboratory equipment. Its compact design—dimensions are approximately 1½" diameter, 2½" high—permits its use in standard coils or elements.

HERE'S A TYPICAL USE IN RESTAURANT COFFEE WARMERS

The new "EU" Control extends slightly above the coil. In this position the heat is off. But when a container of coffee is placed on it, the coil heats up to the pre-calibrated temperature of 180°F. Then it holds this temperature regardless of the amount of coffee in the container. It eliminates the problem of too much or too little heat.

For complete data write Department 41-1-EU2.

Robertshaw-Fulton CONTROLS COMPANY

ROBERTSHAW THERMOSTAT DIVISION • Youngwood, Pennsylvania

Catalogs and Bulletins.....continued

000 psi and temperatures to 1000 F. Information on reaction vessels, superpressure valves, tubing and fittings, both hydraulic and gas booster pumps, compressors, pressure generators, pressure balances, and dead-weight gages. A temperature-conversion table has been included. With dimensional drawings, pictures and cross-sections. American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.

Circle 46, inside back cover

CONVEYOR CHAIN AND SPROCKETS—Bulletin DC-103-A, 2 pp. Conveyor chain designed for higher speeds and loads is described. Browning Mfg. Co., Maysville, Ky.

Circle 47, inside back cover

STANDARD GEAR SETS — Bulletin 700-C, 16 pp. Drawings for all worms and gears, tool charts and ratings for gear-set combinations, backlash tolerances, lubrication data and service factors. Ordering information is given. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12.

Circle 48, inside back cover

SIZING AND FINISHING INTERNAL DIAMETERS—Catalog BZQ-11, 16 pp. Includes description of ballizing process in which balls are pressed through holes to size and finish them. Typical applications are given and tables are provided for performance, production and cost data. Ballizing equipment is shown in actual use. Industrial Tectonics, Inc., 3686 Jackson Rd., Ann Arbor, Mich.

Circle 49, inside back cover

CONSTANT-FLOW CONTROL VALVE—Bulletin, 8 pp, explains design, construction and performance characteristics of the diaphragm-type, nonlubricated valve designed for use where pressure in a fluid line fluctuates. Kobe, Inc., 3040 E. Slauson Ave., Huntington Park, Calif.

Circle 50, inside back cover

TRANSISTORS—Data chart, 8 pp. gives technical specifications and application data for almost 500 transistors now available, and includes over 170 new types introduced recently. Kahle Engineering Co., 1313 7th St., North Bergen, N. J.

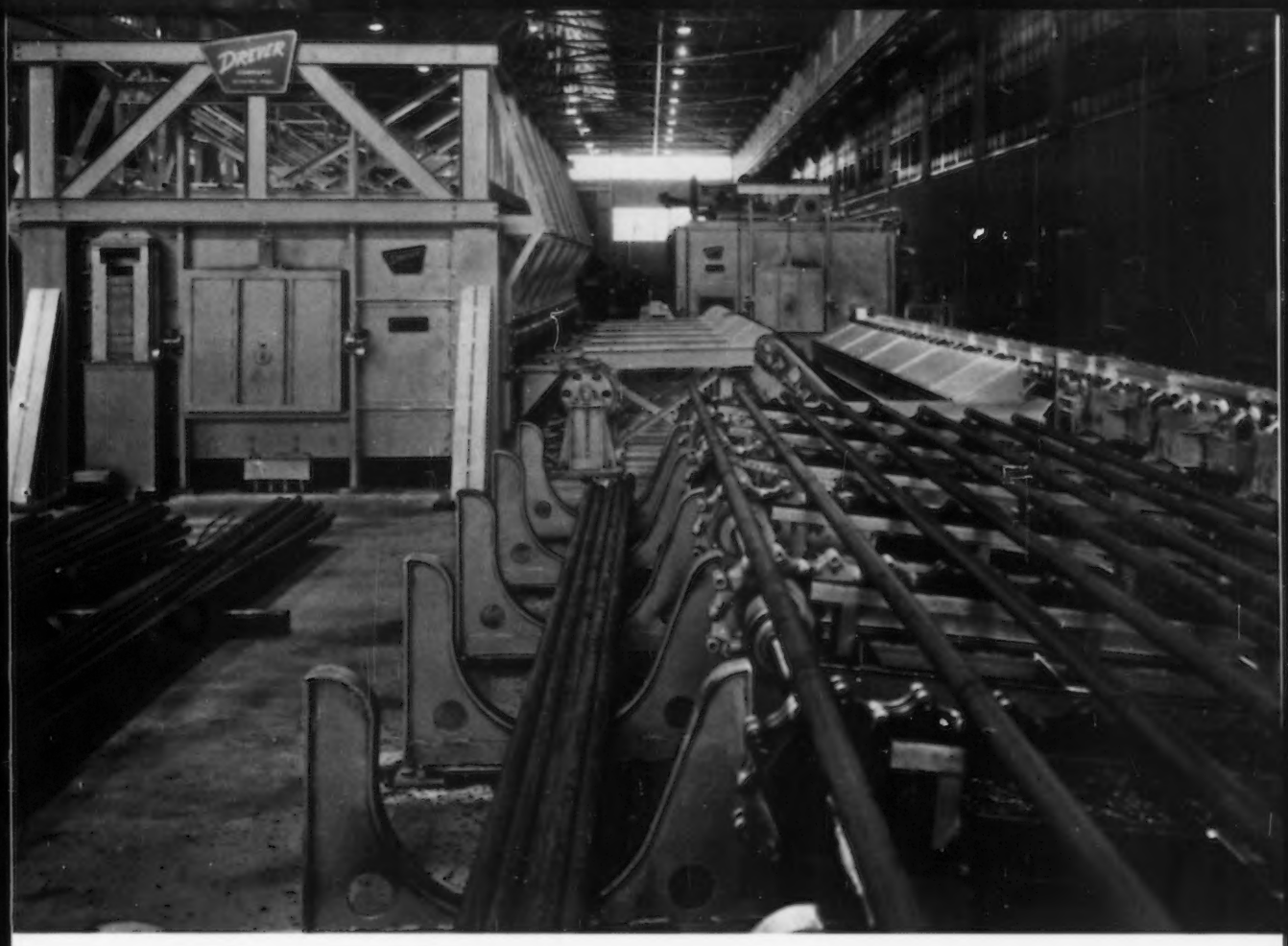
Circle 51, inside back cover

BEARING METAL—Folder, 4 pp. Presents a test on bearing made of metal called "Bearium." Illustrated in four colors with detailed description. Bearium Metals Corp., 190 Mill St., Rochester 14, N. Y.

Circle 52, inside back cover

BALL BEARINGS—Brochure, 4 pp. Describes and illustrates one-piece race type with ball cage. Spec tables and dimen-

(Continued on page 129)



New Continuous Heat Treating and Tempering Furnaces Insure Close Temperature Control

Produce 400 series stainless bars to uniform hardness requirements

Known as the quench and temper method, this new Drever Long Bar Furnace, recently installed at J & L's Stainless Steel Division in Detroit, insures a more uniform hardness in stainless steel bars. It can handle a variety of sizes and shapes from ½ to 4½ inches in diameter and up to 30 feet in length.

This furnace is designed so that it can be switched from a normalizing to a quench and temper operation without interrupting its continuous operation.

With the addition of this new furnace, J & L's Stainless Steel Division can now offer its customers the uniform hardness they require today in stainless steel bar stock . . . just another reason why J & L is a leading producer of quality stainless steel bars.

This quality control, plus the ability to ship a wide range of finished stainless bar stock . . . immediately from inventory . . . is an unbeatable combination that J & L offers to its customers.

Why not write today for our latest stock lists, or for quotations on finished bars or billets?

Jones & Laughlin
STEEL CORPORATION
STAINLESS STEEL DIVISION
Box 4606 • Detroit 34, Michigan

Improve your Products with . . .

J&L STEEL STAINLESS
BAR • WIRE • BILLETS

ONLY Eastman

CAN GIVE YOU THIS COMBINATION...

EXCLUSIVE EASTMAN PACKAGE

1 **_Exclusive_ Eastman Inter-Lock® Clamp for Best Hose Connection.**

Exclusive grip advantages offered in no other clamp. Accurate machining assures positive positioning. Hose is uniformly compressed between insert and clamp without pinching or weakening, creating Eastman's exclusive "Inter-Lock" grip.

2 **Eastman Split Flange for Tighter Seal at Higher Pressures.**

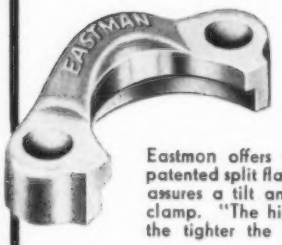
Cuts production and replacement costs with a No-Thread, No-Leak "O" Ring Connection which eliminates tapered threads, sealing compounds and spiral leaks—as well as housing distortion.

Only Eastman can give you this Split Flange Clamp and exclusive Inter-Lock Coupling Combination. *Only* when you specify Eastman can you get the advantages of both. *Only* Eastman can give you this convenient one-source package.

This combination is ideal for *Original* heavy duty equipment. It is the only answer to high pressure requirements because it meets highest OEM specifications and easy field replacement needs.

Available with stem inserts in angles from 0° thru 90°; sizes from ¼" thru 2"; recommended pressures from 375 p.s.i. to 5000 p.s.i.

Look to Eastman . . . America's No. 1 OEM specification . . . for all your fluid power line requirements . . . for the best assembly, the best performance, the best service. Eastman is also recognized for its leadership in engineering design and development . . . backed by unequalled years of experience in the field. *It pays to submit your original specifications for your first quotation to Eastman!*



EASTMAN SPLIT FLANGE

Eastmon offers you the famous patented split flange design which assures a tilt and blowout proof clamp. "The higher the pressure the tighter the 'O' Ring seal."

Eastman "O" Ring Boss Fittings

Now available with new "Back-up" washer and locknut eliminating "O" Ring extrusion per SAE specifications.

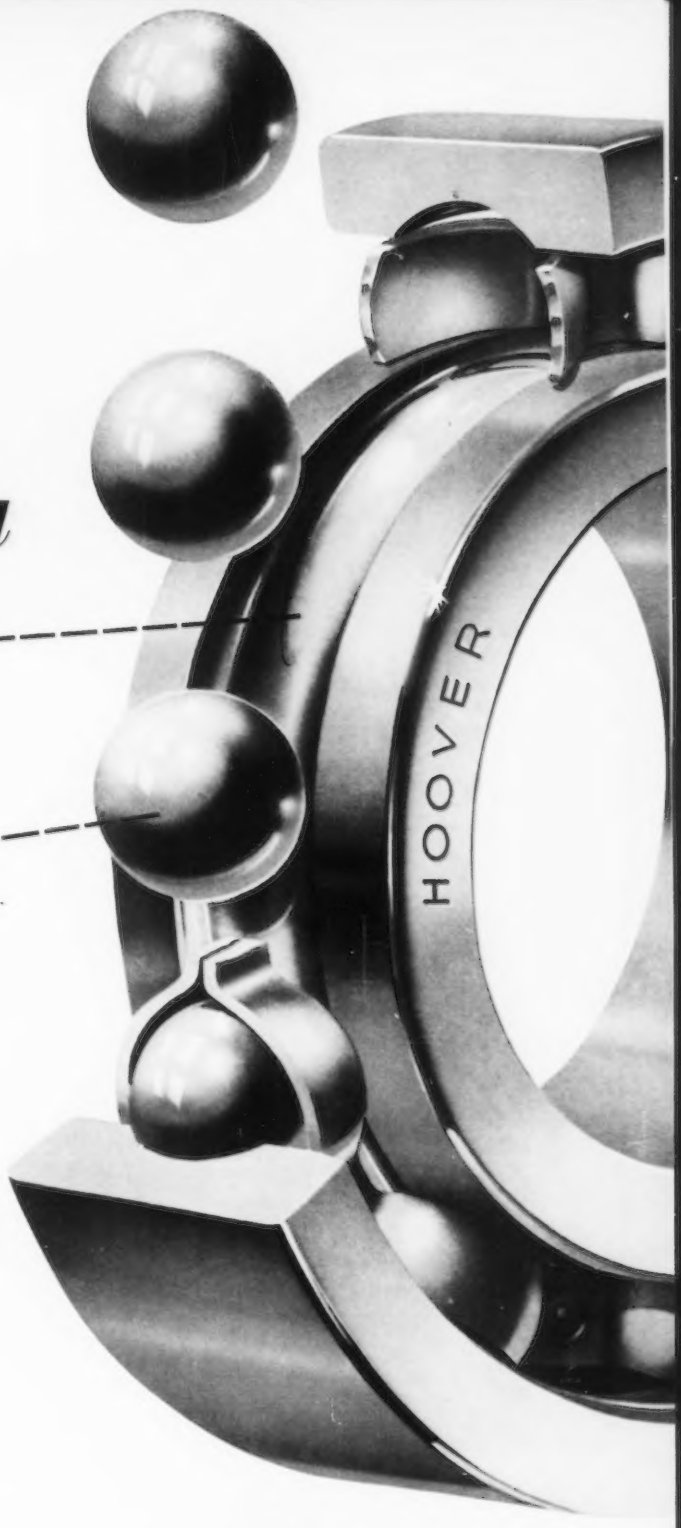
Eastman
first in the field

Manufacturing Company
Dept. PE-1
Manitowoc, Wis.

DESIGN AND DEVELOPMENT ENGINEERS:

Write for Technical Bulletin 200 for Information and Specifications on Complete Eastman Line of Hydraulic Hose Assemblies, and Bulletin 40 on Inter-Lock clamp.

only hoover gives you



Hoover Honed Raceways

which are not only ground, but also fully honed with a unique process developed and used only by Hoover. The result: super smooth, superbly finished raceways of microscopic accuracy and perfection.

Micro-Velvet Balls

made of the finest of selected high carbon chrome alloy steel, uniformly hardened throughout, then surface finished so perfectly that roundness and diameter are accurate within *millionths* of an inch! The gleaming surfaces are absolutely free of even the tiniest of defects.

Perfectly Matched

ball complements are fitted into perfectly matched raceways . . . a final quality step that pays off in maximum load capacity, hushed quietness and extra long life for which Hoover Ball Bearings are so well known. Bearing types available: single row, single and double shield, combination felt seal and shield, double row, cartridge, single and double contact seal.

Hoover Honed and *Micro-Velvet* are Hoover Trademarks

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BALL AND BEARING COMPANY

ANN ARBOR, MICHIGAN

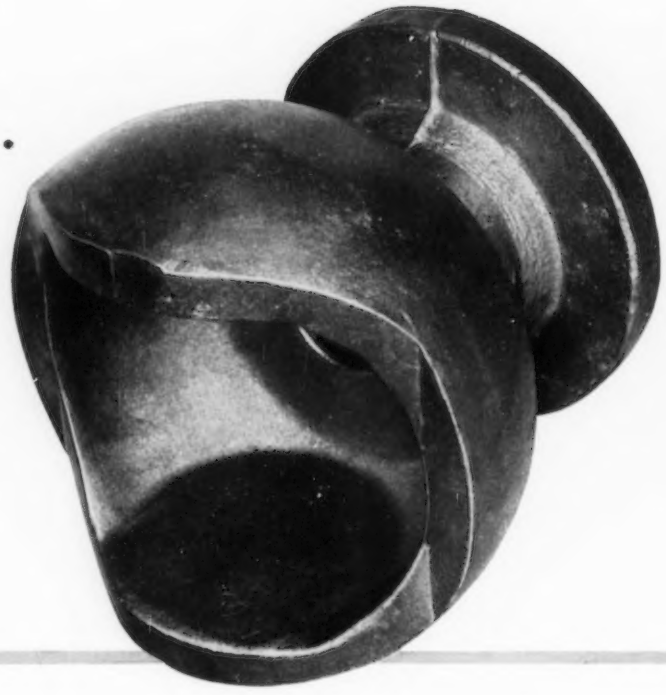
SALES OFFICE AND WAREHOUSE: 2020 SOUTH FIGUEROA, LOS ANGELES 7, CALIF.

WRITE FOR YOUR COPY OF THE HOOVER HANDI-BOOK OF ANTI-FRICTION BEARINGS.

Keep accurate, concise information at your fingertips to help you select proper bearings and solve bearing problems.

unusual design in upset forging...

BALL-JOINT HOUSING for the steering and driving mechanism of the Clark Equipment Company's line of Four-Wheel Drive MICHIGAN End Loaders and Turbo-Dozers formerly produced as a steel casting is now turned out by Commercial as a closed-die forging on an 8-inch upsetter.

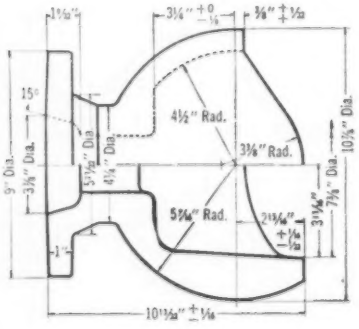


80 lb. forging replaces 95 lb. casting

A saving of 15 lbs. of metal on each housing component is only part of the impressive cost cutting story made possible at Clark Equipment Company by a switch to upset forgings.

When the parts were produced by Commercial as closed-die forgings on an 8-inch upsetter Clark Equipment reported:

1. An initial cost saving of 90¢ per part.
2. Closer tolerances for a 10% machining cost saving.
3. No rejects due to hidden metal defects.



UNUSUAL SHAPE and characteristics notwithstanding — flanged on one end, belled on the other, and open on both ends—Commercial engineers proved this part could be produced as an upset forging with greater cost savings.

Now, this important component not only costs Clark less per unit, but because of its controlled grain flow and efficient metal distribution it provides maximum tensile and torsional strength to resist unusual operating strains as well as massive and unpredictable shock and load. Longer operating life and trouble-free performance are assured.

And because forging impact and pressure produces a more dense, more uniform metal structure, forged parts absorb and dissipate heat at a uniform measurable degree. Obviously, that means elimination of distortion problems in heat treating. It also means fewer rejects during machining, since this dense uniform forged metal has no hidden internal flaws.

With new forging techniques continually unfolding to meet specific job requirements, more original equipment manufacturers are increasingly looking to upset forging to help solve their component forming problems—stronger, lighter, more compact parts at less cost per unit.

Many parts like this unusually shaped housing for Clark Equipment, which were formerly considered impossible to forge, are now routine at Commercial. An early check with Commercial's forging engineers on your particular component forming problem may pave the way for improvement in your product design and production methods—could save you time, money, and help improve performance and operating life.

WHEN AN UPSET FORGING?

Check your part forming problems against this list of "bench marks" for parts requiring:

- Reduced weight, thinner section, greater strength.
- Consistent soundness — no losses due to porosity.
- Good appearance—smooth, close-grained surface.
- Superlative shock and fatigue resistance.
- Uniform response to heat treatment.
- Cost-cutting advantages in finishing—less waste metal, reduced machining, no rejects due to hidden flaws.

Address The Commercial Shearing and Stamping Company, Dept. G-4, Youngstown 1, Ohio.

COMMERCIAL
shearing and stamping

sional drawings are included. Schatz Mfg. Co., Poughkeepsie, N. Y.

Circle 53, inside back cover

PACKAGED SPEED-CONTROL DRIVES—Bulletin 20,000, 8 pp. Describes basic circuit and modifications available. Major components are pictured and described. Explains drive features, lists and shows typical applications with specs. Clark Controller Co., 1146 E. 152 St., Cleveland 10.

Circle 54, inside back cover

AXIAL FLOW FANS—Bulletin 5703, 4 pp. Describes aircraft, electronic, commercial and marine applications, with actual and potential design ideas. Illustrations show package design. Specs for the entire line are given in table form. Axial Flow Fans, Pesco Products Div., Borg-Warner Corp., 24700 N. Miles Rd., Bedford, Ohio.

Circle 55, inside back cover

SOLENOID VALVES—Bulletins E-228, E-229, E-230, E-231, 2 pp each. Dimensions, valves specification, capacity and coil-kit replacement charts for different models are given. A-P Controls, 2450 N. 32nd St., Milwaukee 45.

Circle 56, inside back cover

PRINCIPLES OF MICRORADIOGRAPHY—Book, 48 pp. Text treats contact and projection techniques, X-ray microscopy, definition, geometrical blurring, film unsharpness, unsharpness caused by movement, specimen-preparation techniques and applications. Bibilography has almost 500 references. Instruments Div., Philips Electronics, Inc., 750 S. Fulton Ave., Mt. Vernon, N. Y.

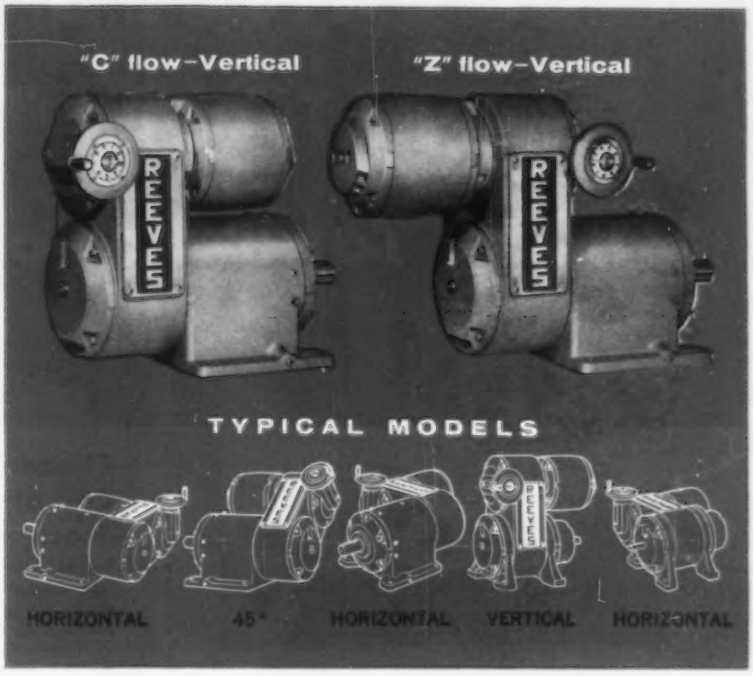
Circle 57, inside back cover

"Honest, Chief, we didn't know it was loaded."

NEW **REEVES**®

*Sizes 200-300 Vari-Speed MOTODRIVES**

**200-300 Size, 1 through 5 hp.; full line, ¼ through 40 hp.*



The flexible design of these compact new REEVES variable speed power packages permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements. All models are available in both "C" flow and "Z" flow styles.

New increased capacity is built in the reducers—single, double or triple stages...new disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

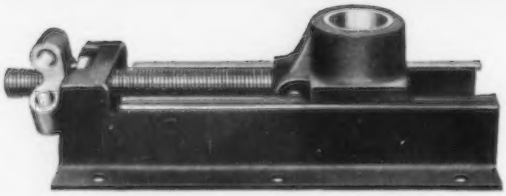
Complete information on all phases of the versatile 200-300 sizes Vari-Speed Motodrives is given in new Catalog. Write for your free copy today—Dept. K32b-M571.

REEVES PULLEY COMPANY

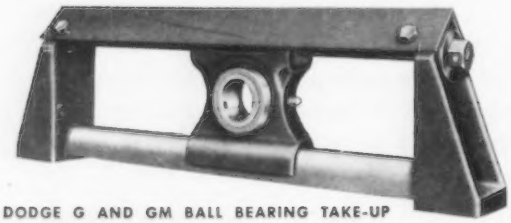
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

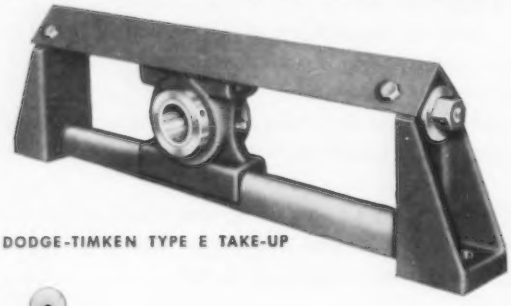
For a BALANCED INSTALLATION *fit the Take-Up to the job!*



DODGE TYPE A TAKE-UP...BABBITTED



DODGE G AND GM BALL BEARING TAKE-UP



DODGE-TIMKEN TYPE E TAKE-UP

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new methods. Look for his name under "Power Transmission Machinery" in your classified telephone book, or write us.

Choose from America's Complete Line of Stock Models and Sizes

For the latest information on take-ups, call your Dodge Transmissioneer. With a complete line available from stock, he is in a position to recommend impartially the take-up best suited to your conveyor system, and to save you money. Babbitted, Bronzoil, Ball and Roller Bearing types in shaft sizes from 1/2" to 4-15/16". Write us for literature.

DODGE MANUFACTURING CORPORATION
1200 Union Street • Mishawaka, Indiana

LIGHT DUTY
BRONZOIL
1/2" to 1"

NORMAL DUTY
SC and SCM Ball Bearing
3/4" to 2-7/16"
G and GM Ball Bearing
1-15/16" to 2-7/16"
TYPE A Babbitted Bearing
15/16" to 2-7/16"
TYPE B Babbitted Bearing
15/16" to 2-7/16"
TYPE H Babbitted Bearing
1-15/16" to 3-15/16"

HEAVY DUTY
TYPE E Dodge-Timken Bearing
1-3/4" to 3-15/16"
ELEVATOR BOOT Dodge-Timken
1-3/16" to 2-15/16"
ANGLE FRAME Dodge-Timken
1-11/16" to 4-15/16"

DODGE
of Mishawaka, Ind.

DESIGN ABSTRACTS

Flow and Fracture

Machines and devices have been designed that cannot be built, because of inadequacies in available materials, inadequacies largely caused by our inadequate knowledge of crystalline structure at the atomic level. Some of the achievements of solid-state physicists in overcoming these limitations are described, and the metallurgist's relationship is discussed. Crystal structure, strain hardening, creep, solution hardening, hardening in two-phase systems, fracture, nonmetalic crystals and their influences on properties of materials are individually examined.

Abstracted from "Flow and Fracture," by E. R. Parker, Univ. of California, Metal Progress, Nov. 1957, 7301 Euclid Ave., Cleveland 3.

Engineers, Do Your Own Writing

This article points out why the technically trained man should write his own memos, reports and articles. Reasons given are summed up under these headings: (1) accuracy, (2) completeness, (3) prestige, and (4) service to his profession.

Abstracted from "Engineers, Do Your Own Writing," by J. L. Kent, Consolidated Electrodynamics Corp., Electronic Industries, Dec. 1957, Chestnut and 56 St., Philadelphia.

Economics of Component Selection

A prerequisite for the best equipment to suit a particular requirement is a thorough knowledge of the economics, selection, application, and performance of component parts. A working formula for determining the cost of a part is developed here. A continuous field-surveillance program is suggested, correlating lab and design procedures with actual field-equipment and component-part failures. Also, a constant watch must be kept on inspection of incoming component parts, to see whether the part manufacturer is providing a reproducible product within the specified limits.

More engineering effort may make it possible to use component parts with broader design tolerances. Reducing the number of component parts may increase reliability and at the same time cut manufacturing costs. Higher reliability may also be achieved by increasing the number of component parts to allow use of lower-cost parts with broader tolerances. Likewise, the most economical results may be realized by duplicating components or using periodic-maintenance, marginal-testing methods.

Abstracted from "Economics of Component Parts Selection," by E. F. Friegel, International Business Machines Corp., Electrical Engineering, Nov. 1957, 33 W. 39th St., New York 18.

Shortcut for Holding-magnet Design

Complex equations are eliminated by method discussed. Instead, high-school algebra is used to obtain magnet dimensions.

The quarterly publication of Indiana Steel Products Co., world's largest manufacturer of permanent magnets, presents illustrations of 24 basic designs for holding magnets that can be used in holding assemblies with any required pull force. (See also Sept. 30, '57, p. 94.)

Abstracted from "Shortcut for Holding Magnet Design," by R. A. Schotten, Indiana Steel Products Co., Valparaiso, Ind., Applied Magnetics, Oct.-Dec. 1957.

Department of Scientific Confusion

A report in *The Chemical Digest* published by Foster D. Snell, Inc. offers some cogent pointers on how to make scientific reports more scientific. Several methods are offered but the principles can be illustrated by a simple mathematical example.

"Every new engineer must learn early that it is never good taste to designate the sum of two quantities in the form:

$$1 + 1 = 2 \qquad (1)$$

"Anyone who has made a study of

(Continued on page 132)

FLEXIDYNE
THE DRY FLUID DRIVE
100% efficiency at full load!

TAPER-LOCK
STEEL CONVEYOR PULLEYS
Maximum strength with minimum weight!

ROLLING GRIP
FRICTION CLUTCHES
Pos'tive! Smooth! No toggles!

•

Write for Bulletins!

- Flexidyne Dry Fluid Drives and Couplings. Bulletin A-640-A.
- Taper-Lock Steel Conveyor Pulleys. Complete data. Bulletin D-56.
- Rolling Grip, Diamond D, Air-Grip Clutches. Bulletin D-56.

DODGE MANUFACTURING CORPORATION
1200 Union Street • Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

ROTARY AIR
GAST
PRODUCTS

Model 3040 Oil-less Air Pump. Up to 20" vacuum, up to 10 p.s.i. pressure. Capacity to 24 c.f.m.

Provide oil-free air blast with any of the carbon-vane

GAST rotary vane AIR PUMPS

Model 0240, 0440, 0740 Series Oil-less Air Pumps. Three displacements, from 1.9 to 5.6 c.f.m. Vac. to 15", pressure to 10 p.s.i.

Model 0211-P103-G8X Integral-Motor Oil-less. Up to 1.3 c.f.m. Motor 1/6 h.p. Wt. only 22 lbs. Smaller Model 0406 Oil-less has 1/12 h.p.

Need a pump that delivers absolutely *oil-free* compressed air? A Gast Oil-less Air Pump may be your answer! Built in seven different models — vacuum or pressure — these pumps* run *entirely without oil* in the pumping chamber.

Four carbon vanes lubricate themselves. Ball bearings are grease-sealed for life and separated from pumping chamber by a ventilated space. Air flow can't be contaminated with hot oil vapor.

You can *forget* oiling maintenance problems too! Simple construction delivers up to 15,000 hours' operation without attention, depending on r.p.m. and service conditions. This is a big advantage, especially when your product requires a compressor or vacuum pump mounted in a hard-to-service location.

Widely used on food-packaging, paper-handling, folding and laboratory machines.

Write for full details — request Bulletins 152A and VP-356. GAST MANUFACTURING CORP., P.O. Box 117-V Benton Harbor, Michigan.

*Standard oil-lubricated models also available.

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

advanced mathematics is aware that:

$$1 = \ln e$$

and that

$$1 = \sin^2 x + \cos^2 x$$

further:

$$2_2^1 = \sum_{n=0}^{\infty} \frac{1}{2^n}$$

Therefore eq. (1) can be expressed more scientifically in the form:

$$\ln e + (\sin^2 x + \cos^2 x) = \sum_{n=0}^{\infty} \frac{1}{2^n} \quad (2$$

"This may be further simplified by use of the relations:

$$1 = \cosh y \sqrt{1 - \tanh^2 y}$$

$$e = \lim_{z \to \infty} \left(1 + \frac{1}{z}\right)^z$$

Eq. (2) may therefore be rewritten:

$$\ln \left[\lim_{z \to \infty} \left(1 + \frac{1}{z}\right)^z \right] + (\sin^2 x + \cos^2 x)$$

$$= \sum_{n=0}^{\infty} \frac{\cosh y \sqrt{1 - \tanh^2 y}}{2^n} \quad (3)$$

"At this point it should be obvious that Eq (3) is much clearer and more easily understood than Eq (1). Other methods of a similar nature could be used to clarify Eq (1) but these are easily discovered once the reader grasps the underlying principle."

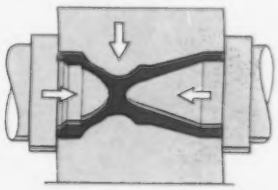
"Now this first job will tax your ingenuity and mathematics . . . see how many strokes it takes you to get around the floor with this . . ."

NO WONDER WE MAKE SO MANY

CAMERON ONE PIECE FORGED MISSILE NOZZLES

1. Have no welds
2. Require less machining
3. Are lower in cost

A better nozzle for less money has put Cameron way ahead in production of these important missile parts. Cameron's exclusive split-die forging process makes this possible. Each nozzle is forged from a single heated billet of specified steel. This steel is produced in Cameron's own melt shop under the closest possible control. From these perfect billets our specially designed split-die presses forge a near final shape.



Movement of the three elements in the split-die process.

No welds are required and machining is greatly simplified—grain structures are perfect.

Missile nozzles produced by this method are supplied as finished forgings ready for economical machining or completely machined to specification. At every single phase of manufacture, each nozzle is checked by the most modern methods used today.

The Cameron split-die process has successfully solved many unusual forging problems in a wide variety of end uses. Some of these include critical airframe members, jet engine components, propeller blades and hubs, atomic reactor valves and many high pressure controls for the oil industry.

Cameron has extended the great advantage of ferrous forged members to include shapes impossible to produce heretofore. Present production of missile nozzles includes diameters to 28" with large open sections and elongated double conical thin sections to 36" in length. In weight our forgings range to 8,000 lbs and our high quality alloys satisfy many unusual demands. If you need forgings in this group and, of course, if you need nozzles, call, write or come by . . .

Cameron

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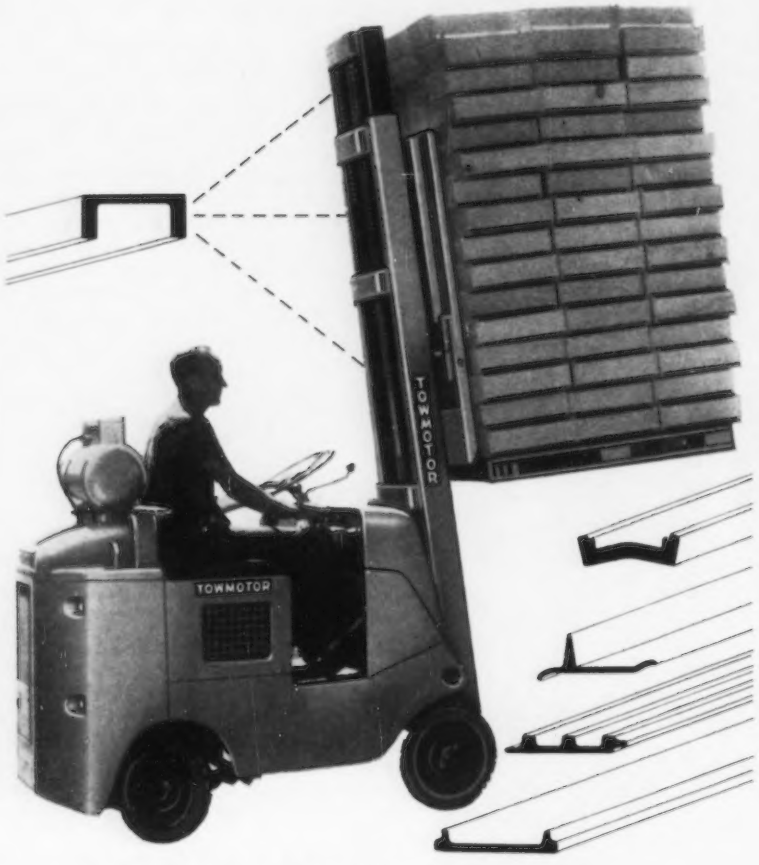

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Why perform three operations when special sections can be rolled in one? Take the upright in this lift truck. Formerly there was a plate which went through a press brake and was then straightened and machined. Today, the section is rolled for Towmotor in one operation by Connors Steel.

Special sections can open new doors to the design engineer, save time and money and assure ultimate strength. If your requirements justify special rolls, send a sketch or specifications to the Connors Steel Division, H. K. Porter Company, Inc., plant nearest you for free Engineering Consultant Service.

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CONNORS STEEL DIVISION

NEW BOOKS

Principles of the Properties of Materials

JACOB PORTER FRANKEL, *Dept. of Engineering, U. of California. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 36. 9¼x6½, 228 pp. $6.*

This study takes a new approach to its subject by emphasizing principles and properties, rather than materials. The author believes that a knowledge of principles will prepare the student to solve not only the difficult problems of today's advanced technology but also those of the future.

Materials go in and out of fashion, but are always replaced by those designed on the basis of required properties. The engineer who understands even a few major principles has a better grasp of materials problems than one with equivalent study of metals, concrete, wood, or plastics. The book is based on a series of lecture notes prepared for sophomore classes in the properties of materials at Northwestern Technological Institute.

Each chapter opens with a synopsis of important principles. The body of the chapter derives and describes use of these principles. Questions end each chapter.

Thermal Stresses

B. E. GATEWOOD, *Air Force Institute of Technology. Published by McGraw-Hill Book Co., 330 W. 42nd St., N. Y. 36. 9¼x6½, 232 pp. $7.50.*

Missile and aircraft designers are increasingly confronted by high temperature problems. These become more acute as speed increases, and within a few years will unquestionably be the limiting factor in performance.

This engineering book is for aeronautical designers in particular. The material is well organized, with emphasis on fundamental theory. The treatment is applicable to many types of machines other than aircraft—nuclear reactors, rocket motors, steam and gas turbines and their design, and guided-missile air frames.

All phases of the analysis and design of structures at elevated temperatures

(Continued on page 136)

129 Hydraulic Pump and Motor Combinations

Here are power sources for any hydraulic application. Commercial, military, and aviation research have developed this array of standard pump and motor combinations.

With a performance range from .1 to 5 G.P.M. at pressures to 2000 P.S.I., you can expect a stock power source that fits your requirements. Many types of motors offer a choice of electrical characteristics, and have drip-proof, totally enclosed, or explosion-proof enclosures as required.

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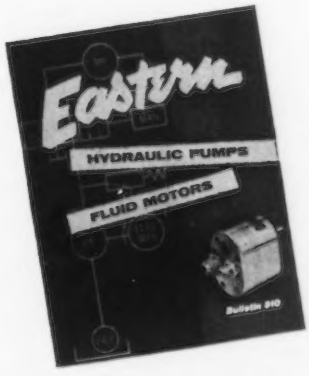

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are covered, including temperature distribution, elastic and inelastic thermal stresses, combined applied and thermal stresses, allowable stresses of various materials at elevated temperatures, and the buckling, deflection, stiffness, fatigue, shock and flutter effects of elevated temperatures.

The thermal-stress calculation procedures developed here are considered as accurate as some of the other steps in the design sequence, and more accurate than temperature based on convective heat-transfer calculation and the allowable compressive stress under creep condition. The most recent advances in thermal stresses, temperature distributions, and material properties have been included. Many procedures are published for the first time.

Atomic-energy Facts

Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., Paperbound, 7¾x10¼, 216 pp. $2.

From access permits to research reactors, this volume gives a quick rundown of major activities in atomic energy. It contains no new material, and concentrates on power reactors (there is only one short chapter on isotopes, for instance), but it does bring together much information that would otherwise have to be obtained from a number of sources: A speech on the basic principles of thermonuclear energy, a list of reactors built and building, charts of basic reactor types.

Screw-Thread Standards for Federal Services

Handbook H28 (1957)—Part I, amends in part H28 (1944) and in part its 1950 Supplement. Issued Sept. 10, 1957. Order from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 214 pp. $1.25.

This publication represents the work of the Interdepartmental Screw-Thread Committee, which is sponsored by the Dept. of Defense, Army, Navy, Air Force and Commerce to promote uniformity in screw-thread standards in the department concerned. It presents complete dimensional data upon which specifications may be based for threaded products

(Continued on page 138)

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Fractional H. P. Motors

1/40 H. P. to 1/1100 H. P.

Meet an all-around performance champion. GI's husky, versatile Model "A" motor. Proved dependable millions of times over, it's the power choice of the nation's great-name manufacturers . . . setting an amazing performance record in countless applications from phonographs to kitchen fans to pumps. If dependability is your aim, Model "A" is your motor!

MODEL "A" two-pole shaded pole motor available in various lamination thicknesses. Precision constructed for reliable, long hard usage. Perfectly balanced for smooth, quiet, operation.

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SPECIFICATIONS

MODEL	HP 2800 RPM	Locked Torque In/Oz	Max. Running Torque In/Oz	Rotor Free Speed RPM	A
A-3-CW A-3-CCW	1/500	0.70	1.1	3360	3/8"
A-5-CW A-5-CCW	1/180	1.7	2.7	3430	5/8"
A-6-CW A-6-CCW	1/130	1.9	3.3	3430	3/4"
A-7-CW A-7-CCW	1/100	2.1	3.8	3500	7/8"
A-8-CW A-8-CCW	1/90	2.5	4.5	3480	1"
A-9-CW A-9-CCW	1/70	2.7	5.3	3520	1 1/8"
A-12-CW A-12-CCW	1/60	3.0	6.5	3500	1 1/2"
A-14-CW A-14-CCW	1/50	3.1	7.0	3490	1 3/4"

Standard shaft diameter .1817, 1/4" shaft available if desired.

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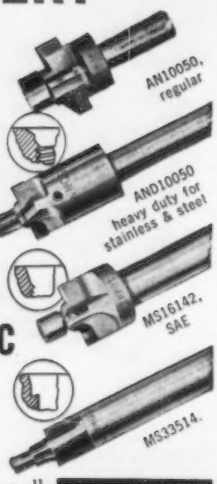

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for Government requirements. These data conform to generally accepted commercial practice, although certain special requirements of the Government necessitate inclusion of some standards not generally applicable commercially. References are cited throughout the text to other standards.

Included are specs for threaded products and gages, embodying sufficient information to permit the writing of complete specifications for the purchase of screw-thread products. In the appendixes there is supplementary general and technical information.

Handbook of Layout and Dimensioning for Production

HYMAN H. KATZ. *Published by MacMillan Co., 60 Fifth Ave., New York 11. 6¼x9½, 480 pp. $15.00*

This book is designed to help apprentice on-the-job draftsmen graduate to more challenging assignments. It is not intended as a textbook for the young engineer. A draftsman using the handbook can be expected to do detail work with less supervision, and progress to design responsibility more quickly—taking some of the load from the hard-pressed design engineer.

The book provides know-how not offered by a conventional academic approach to engineering drawing. It stresses practical, industry-defined layout and dimensioning requirements. Each step, from technical sketch to final drawing, is illustrated and detailed in terms of procedures, principles and theory.

Transistor Electronics

DAVID DEWITT and ARTHUR L. ROSSOFF. *Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36. 6¼x9¼, 370 pp. $8.*

A comprehensive treatment of transistor technology, including several chapters on basic physics of semiconductors and ample material on all electronic theory associated with transducers. Uses many derivations, circuit diagrams, and practical examples to discuss feedback, performance, amplifier circuits, high-frequency opera-

tion, switching, mixing, computing, radio receiving and others. Long bibliography and sample problems at end. Reader need not be expert, but needs to be familiar with elementary electronics.

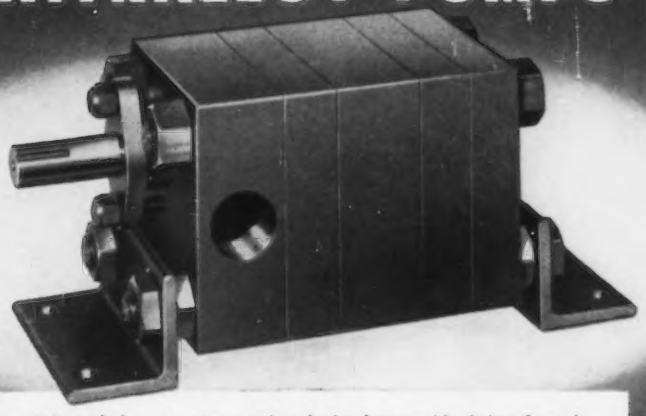
Ultrasonic Welding of Metals

J. B. Jones, C. F. DePrisco, and J. G. Thomas, *Aeroprojects Inc. for Ordnance Corps, Dept of Army, PB 131084. Available from Office of Technical Services, Dept. of Commerce, Washington, D. C. Paperbound,* 8½x11, 89 *pp.* $2.75.

This report covers an extension of ultrasonic welding for foils of aluminum and other methods. Capabilities of the process have been greatly improved through equipment development, and more materials can now be welded this way in a wider variety of gages. Successful welds were made, for example, in 1100 aluminum through 0.062 in. thickness, and showed shear strengths in the same order of magnitude as for the base

(Continued on page 140)

NORTHERN NITRALLOY PUMPS



Unique block construction permits selection from a wide choice of metals for virtually any pumping need. Proven in thousands of installations . . . backed by 50 years of engineering and production experience. Unexcelled for precision manufacture, accurate assembly and dependable, long-life operation. Pressures to 2,000 PSI. Capacities from ¼ to 146 GPM. *Write for free catalog and engineering data.*

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Chelsea Milling Company, maker of well-known "Jiffy" brand premixed foods, uses flexible Cypak* static control to reduce materials-handling costs at its plant in Chelsea, Mich.

Starting at the mixing and packaging machines, Cypak control memorizes the sequence of cartons going to the warehouse . . . maintains carton identification automatically . . . directs storage according to the preselected pattern. In addition, Cypak predetermines subsequent delivery to the loading dock.

Result: substantial savings have been realized through reduced handling and carton breakage.

For complete information on Cypak, call your Westinghouse representative. Or, write Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pennsylvania.

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*Trade-Mark

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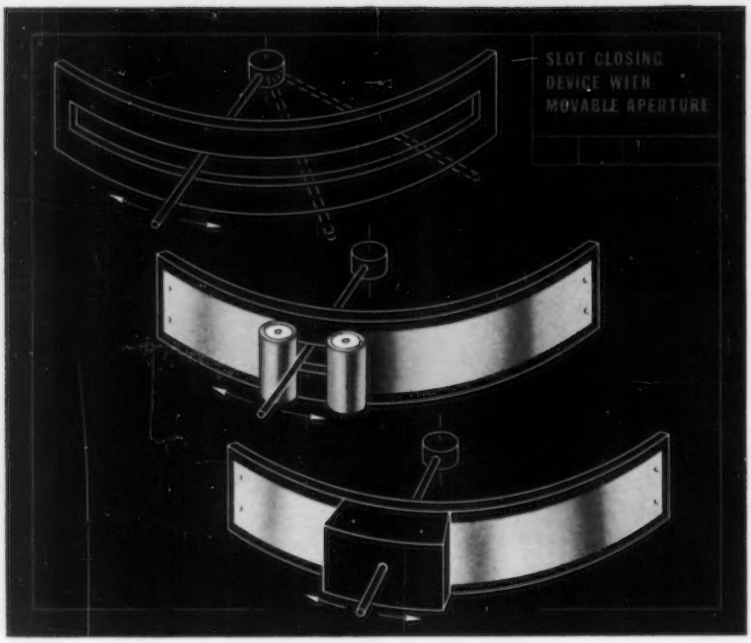
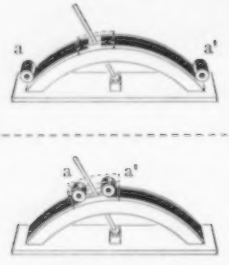


Simplify Slot Closure

WITH NEG'ATOR® SPRINGS



TWO METHODS of mounting NEG'ATORS for slot closure. Above, the free ends of the balanced NEG'ATORS are attached to the traversing unit (the movable aperture) and the NEG'ATOR coils (a and a') are mounted, out of the way, on a stationary section of the equipment. Below, the free ends are fixed and the coils are mounted on the moving member. Where space is available, the mounting below is preferred because of minimized friction.

Paired, equal-force NEG'ATOR Springs, forming flat bands as they uncoil, make an effective cover for slots and provide a movable access through the slot as shown above. This is just another example of how alert engineers have utilized *constant-force* NEG'ATOR Springs to solve unusual design problems.

Slot closure devices incorporating NEG'ATOR Springs are inexpensive, compact and foolproof in operation. Each design utilizes two NEG'ATOR Springs to mask the openings created on either side of the movable aperture. One NEG'ATOR extends as the other re-coils and their equal and unchanging forces counterbalance each other.

Typical application possibilities for NEG'ATOR-equipped slot closure devices include: grinding machine shields, bomber gun turrets, machine tool ways, splash guards, dust enclosures, safety shields, electrical enclosures, and sound baffles—just to mention a few. Can NEG'ATOR Springs solve your particular design problem? Find out more about this versatile component—the first *constant-force* spring—by requesting Bulletin 310N.

HUNTER SPRING COMPANY

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metal itself. No reduction in strength was evident after 5000 hrs exposure in each of two corrosive environments.

Report covers: ultrasonic welding equipment, evaluation of equipment and techniques, welding of metals other than aluminum, including copper, nickel, brass, magnesium, titanium and stainless steel. Most successful results were obtained, however, with aluminum or combinations of the above metals with aluminum. Surface films adversely affected weld strength. Polished surfaces appeared more readily weldable than roughened surfaces.

Engineering Properties and Applications of Plastics

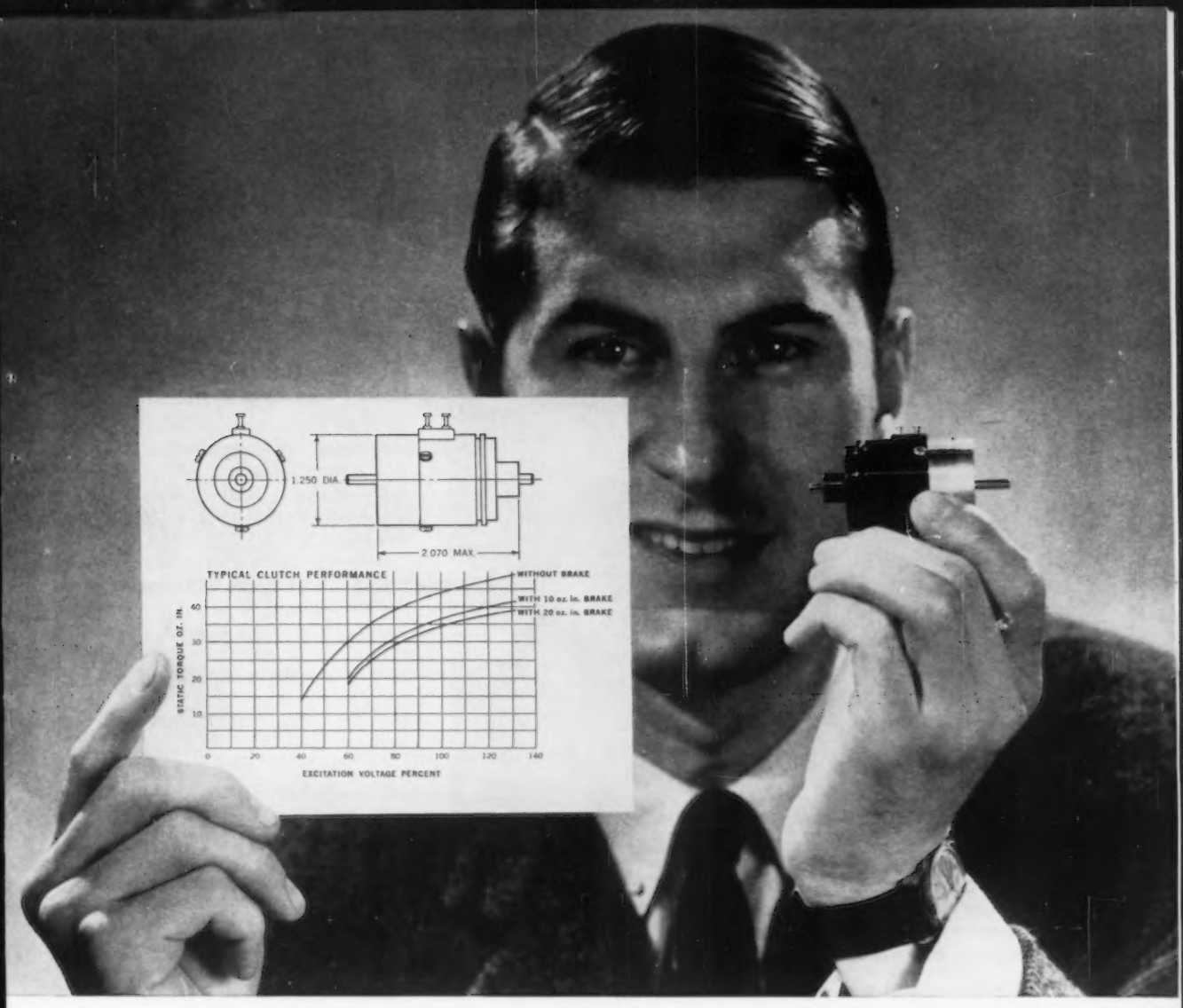
DR. G. S. KINNEY, *Professor of Chemical Engineering, US Naval Postgraduate School, Monterey, Calif. Published by John Wiley & Sons, 440 Fourth Ave., New York 16. 6x9, 288 pp. $6.75.*

This book is for both those who work with plastics and those who require background information for proper use or specification of these materials. The plastics are described in order of increasing complexity, and a unified treatment rather than a topical one has been used, making the book more useful as a reference work.

Separate chapters describe methods of fabrication, as well as mechanical, electrical, optical, and thermal properties of these materials. Emphasis is placed on understanding fundamental nature of plastics. An abbreviated

(Continued on page 142)

"Anything else you shop people want to thrash out with us?"



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Standard Clutches	14 ms.	2 ms.*
Special Clutches	4 ms.	2 ms.*
Standard Clutch Brakes	14 ms.	14 ms.
Special Clutch Brakes	5 ms.	5 ms.
Special units with built-in loads, such as a potentiometer	4 ms.	less than 1 ms.

*when application requires

In general, we can **improve** either engagement or release time, but not both together. Options include voltage choice, input-output shaft position choice. Because standard parts for Globe units are inventoried, and clutch design a specialty, you get prototypes within weeks! Inquire from the largest miniature motor manufacturer first. Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio. Telephone BAldwin 2-3741.

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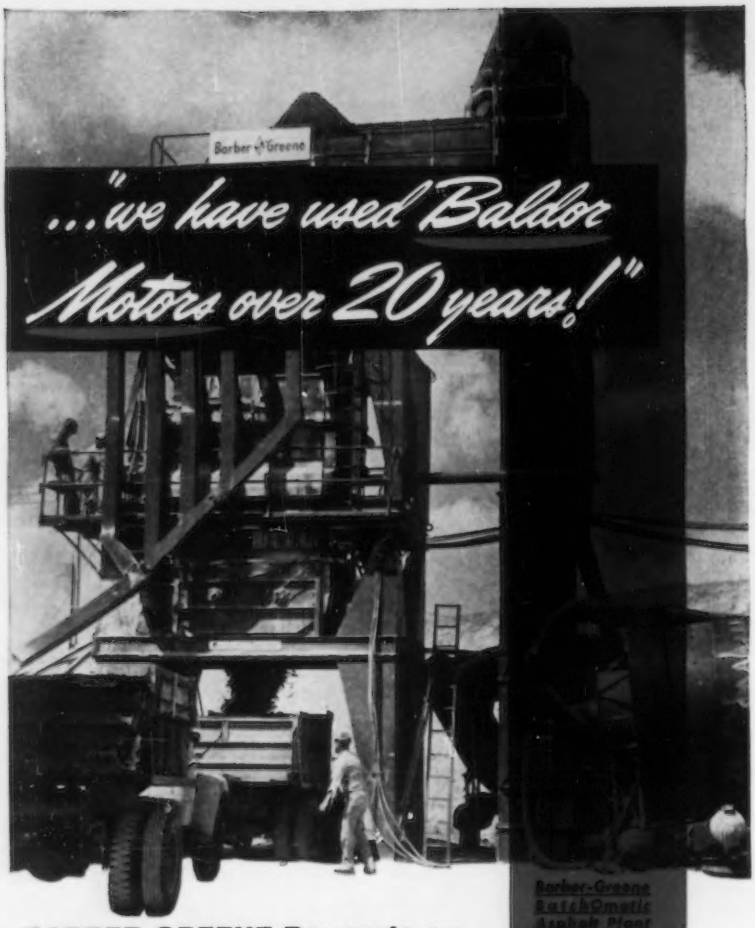

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survey of basic chemical reactions used in their manufacture is included. Some information on various reinforcing methods for plastics is presented, but primary emphasis is on resins themselves, and their properties. A brief but excellent tabular summary of the plastics covered appears at end of the book.

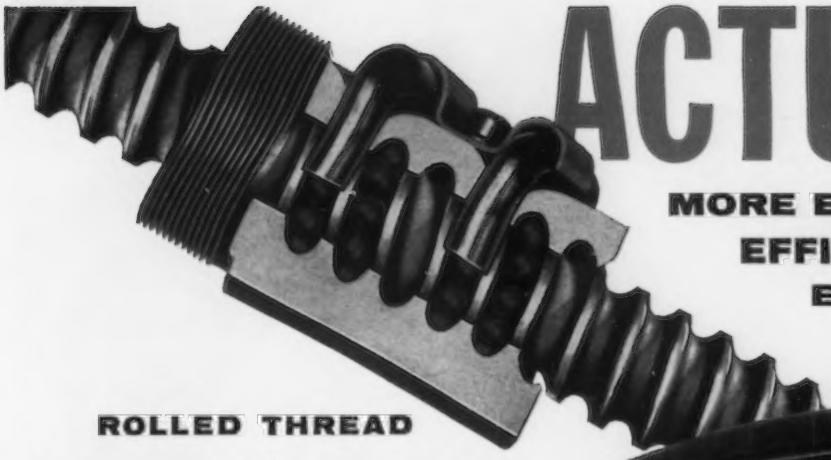
Installing Electronic Data Processing Systems

RICHARD G. CANNING, *Partner, Canning Sisson and Associates; and Associate Research Engineer, UCLA. Published by John Wiley & Sons, Inc. 440 Fourth Ave., New York 16. 6x9, 193 pp. $6.*

Although the author is an electronics engineer and mathematician he has managed to avoid computor theory, presenting a practical discussion of how to prepare for and install an EDPM (Electronic Data Processing Machine) the book is a sequel to his "Electronic Data Processing for Business and Industry."

Essentially this work is a case history of the hypothetical "AAA Company," which, having decided to install an EDPM, followed the step-by-step procedure recommended by experts. The proposed plan, almost four years in duration, is outlined in Chapter 1. The remainder of the book carefully details each step, including operations research, training of personnel, budget, systems planning, procedures, programming of the computers, room design, and installation. The closing chapters recapitulate the whole operation.

"Yesterday we both had the feeling that we were on the brink of something marvelous, but today *we're going to stay sober!"*



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Top-quality Saginaw b/b Screws are the only kind stocked in seven standard commercial rolled thread sizes, cut to desired length, for low cost and fast delivery. Or you can order custom machined screws for critical or extreme precision applications. Saginaw has successfully built screws from 1½ inches to 39½ feet long—⅜ inches to 10 inches diameter.

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Saginaw b/b Screws have been applied to automatic garage doors, automobile seat adjusters and window lifts, barber chairs, hospital beds, bumper jacks and circuit breakers. Or they can be used for heavy industry equipment like die table positioners, drill presses, lift trucks and welders.

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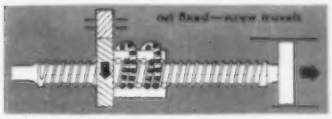
Let Saginaw's experienced engineers help solve your special application problems. Just write or phone us—no obligation.

Automatic Garage Door lifts and lowers easily and smoothly when actuated by Saginaw b/b Rolled Thread Screw.

HOW THE WORLD'S MOST EFFICIENT ROTO-LINEAR DEVICE WORKS

When rotary motion is applied to the screw, the b/b nut is driven along the axis of the screw, changing rotary motion to linear motion with over 90% efficiency.

When rotary motion is applied to the b/b nut, the screw is driven along its longitudinal axis, changing rotary motion to linear motion with over 90% efficiency.



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or see our section in Sweet's Product Design File

Saginaw Steering Gear Division
General Motors Corporation
b/b Screw and Spline Operation
Dept. SPE, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME_____

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Saginaw
ROLLED THREAD ball bearing Screw

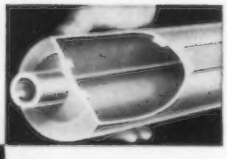
SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

Producing cold-forged rocket launchers for the Chance Vought Crusader is another example of Hunter Douglas ingenuity. The 3" O.D. tube, approximately 100 inches long with an .046" wall, with one end closed, required a fantastic arrangement of internal and external longitudinal ribs, almost impossible to fabricate by conventional methods.

Even cold forging with its ability to integrally form complex part geometry, was put to rigorous tests. For example, cross sections of the tubes were non-symmetrical, generally a serious taboo in cold forging techniques. Further, the non-symmetrical design aggravated longitudinal bow, yet tubes had to be straight within .120" overall. Finally, retention of a minimum wall adjacent to the heavy section presented the problem of uniform metal flow. The heat treated tubes must withstand 1400 psi hydrostatic pressure without deformation.

By combining the varied talents of an experienced engineering staff, good tooling design and sound production techniques, the *cold forged rocket launcher is a fact today*... assembled from two cold forged tubes mechanically joined by a dovetail. Simpler and lighter in design, the cold forged launchers are built to closer tolerances, with greater strength *at less cost!*

If your components can be cold forged, Hunter Douglas can do it! For recommendations, submit your prints or samples.



Section is removed to show internal detail of closed end.

An end sawed from the full length tube illustrates internal and external ribs as well as end detail.

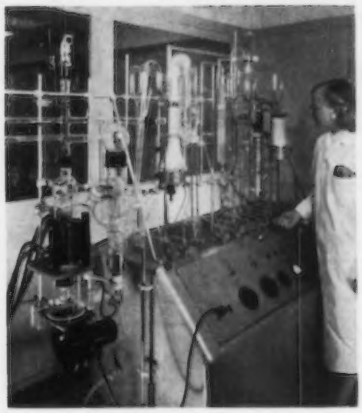
Joining the twin barrels was solved by a dovetailing operation. The wide external rib seen in Fig. 2 provides dovetail area.

Overall tube length is indicated here. Entire unit is one piece. Dovetailing is the only assembly operation required.

Hunter Douglas Aluminum

Division of Bridgeport Brass Company
Dept. PE-1, Riverside, California • OVerland 3-3030

PRESS PREVIEWS



Wallingford Steel Co. Builds New Metal Lab

Wallingford's new quality-control lab at Wallingford, Conn., has an analytical section (shown in part above), a metallurgical section, a special-testing section, library, and conference room.

The analytical section, with X-ray diffractometer and fluorescent spectrographic equipment, will handle: vacuum-fusion gas analysis to determine concentration of oxygen, hydrogen and nitrogen in reactive metals, stainless steel and super metals; Orsat gas analysis of annealing atmospheres in the company's mill; analysis of chemical baths; and corrosion testing for development and production work.

New Plant for ARMA

American Bosch Arma Corp. has opened a new plant in Oak Lawn, Ill., for the design, development, and production of complex test and ground-support equipment. The 20,000-sq-ft plant will employ over 60 engineers.

Fiberglas-yarn Plant for N. C.

Pittsburgh Plate Glass Co. will build a plant to make continuous fiberglass yarn at Shelby, N. C. The multi-million dollar plant will employ about 850 at capacity operation. Structure is scheduled for completion within

(Continued on page 147)

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.

DYNAMIC AND STATIC LOAD RATINGS

Load ratings of MICRO bearings are based on standards established by the Anti-Friction Bearing Manufacturers Association and are the result of extensive tests.

The "life" of an individual bearing is defined as the number of revolutions the bearing makes before the first evidence of fatigue develops. Fatigue, in turn, is a function of bearing load and although other factors, such as contamination and high temperature, affect the life of a bearing, it is assumed that clean bearings running at normal temperatures are being considered.

It is not possible to predict the life of any individual bearing. The problem, therefore, is best approached by a consideration of empirically derived dispersion curves which provide a means of determining bearing life on a probability basis. That is, they permit the average life of a given group of bearings to be accurately specified.

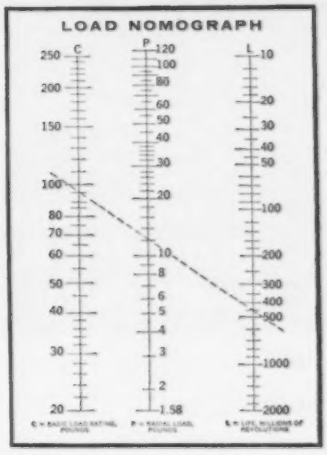
For purposes of standardization, the "rating life" of a group of apparently identical ball bearings is defined as the number of revolutions that 90% of the group will complete or exceed before the first evidence of fatigue develops. This figure is approximately one-fifth of the average life.

If two groups of similar bearings are run under different loads F_1 and F_2 within normal operating range of loading and rpm, their lives L_1 and L_2 are inversely proportional to the cubes of the loads, i.e., The BASIC LOAD RATING C is that radial load which a group of apparently identical bearings can endure for a rating life of one million revolutions, with stationary load and rotating inner ring. Within normal operating ranges, rating life for any load is a constant number of revolutions, so the following relationship, a restatement of the inverse cube proportion, may be used to compute rating life when basic load rating and applied radial load are known:

$$L = \left(\frac{C}{P}\right)^3$$

L = rating life in millions of revolutions
where, C = basic load rating in pounds
P = applied radial load in pounds

The nomograph illustrated permits the quick evaluation of any one of the three quantities when the other two are known. For example, if the C rating of a given bearing is 95 pounds, and the bearing is loaded radially with



12 pounds, P, a straight edge crossing these two values in their respective columns shows that the bearing could be expected to have a life, L, of 450 million revolutions.

"EQUIVALENT LOAD"

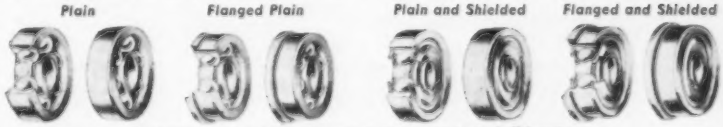
Bearings whose loads are primarily radial are usually also subjected to axial forces. When the axial component of the load is greater than a negligible value, this combined radial and thrust load may be expressed in terms of a simple radial load in order that the basic load rating C may be calculated. This simple radial load is known as the "equivalent load", which is that constant stationary radial load which, if applied to a rotating inner ring, would give the same life as that which the bearing will attain under the actual conditions of load and rotation.

A formula for determining "equivalent load" and a more comprehensive discussion of static and dynamic loads is found in our design handbook.

DESIGN HANDBOOK OFFERED *FREE*

You'll find this new, 70-page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

Write to: New Hampshire Ball Bearings, Inc., Peterborough 1, N.H.

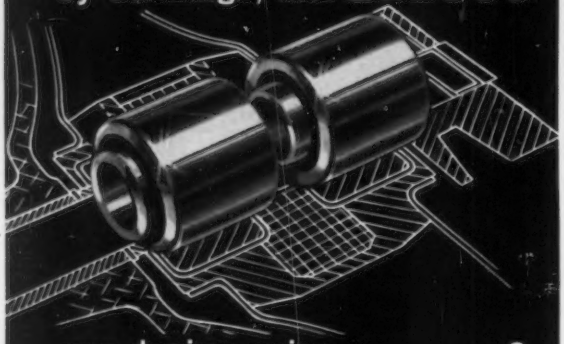


Typical cut-away views of instrument-type retainer ball bearings.

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

District Offices: Pasadena, Calif. Park Ridge, Ill., and Great Neck, N. Y.

when you design • Flexible Bearings by Bushings, Inc. **in...**



you design noise, vibration, shock and shaft-wear **out!**

Custom fabrication by Bushings, Inc. can assist in solving your bearing problems

Whatever you design or manufacture with moving parts—from small appliances to heavy earth moving equipment—you can overcome excess noise, vibration, shaft-wear, misalignment and similar problems by designing Flexible Bearings by Bushings, Inc. IN as original equipment.

FLEXIBLE BEARINGS are custom-fabricated to your specifications. With the bushing manufactured to fit the job, you are no longer restricted to limited "stock" sizes but have complete freedom of design.

FLEXIBLE BEARINGS by Bushings, Inc. have a mechanical bond between the flexing medium and the inner and outer members.

FLEXIBLE BEARINGS by Bushings, Inc. are available in two types: TORSIONAL for oscillating movement; PROTECTIVE for insulating ball, needle and other types of bearings against load, sudden shock, misalignment or noise transmission.

If you want fast, authoritative engineering help on your bearing problems, write Harvey G. Moore at the address below.

• *For more than 15 years Bushings, Inc. has custom-fabricated bearings in a wide range of metals and sizes for hundreds of different manufacturers.*

VIBRO-LEVELER MOUNTS dampen vibration, permit precision leveling of machines.

SILENT-LIGN PILLOW BLOCKS for shaft mounting. Has all Flexible Bearing features.

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Tru-Seal Fittings are guaranteed to seal pipe thread connections permanently against all oils, practically all known chemicals and gases; to seal under high pressures or vacuum; to withstand —280° to plus 500° F.; to eliminate "overtightening" damage and pipe dope.

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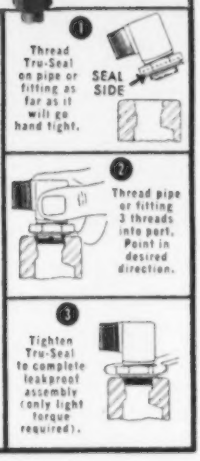
1
Thread Tru-Seal on pipe or fitting as far as it will go hand tight.
SEAL SIDE
2
Thread pipe or fitting 3 threads into port. Point in desired direction.
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Tighten Tru-Seal to complete leakproof assembly (only light torque required).

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In Industry, in homes, farms and shops, you'll find daily, living proof that D-&-B's KNOW-HOW pays out in EXTRA performance. Rely on expert engineers for parts that meet your *exact* needs and save you MONEY! Get *Wire Forms, Springs* and *Stampings* that are easily assembled . . . that withstand stress . . . and perform under the most *trying* conditions!
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4014 W. Grand, Chicago 51, Ill.

12 mo after construction gets underway, and partial production is expected to begin as soon as the building is completed. Design capacity of the plant will make it one of the largest in the fiberglass industry. The new unit will have 16 glass furnaces capable of producing 25 million lb of yarn per year.

New Company to Market Computer

The Ramo-Wooldridge Corp., Los Angeles, and Thompson Products, Inc., Cleveland, jointly announced formation of a new subsidiary corporation, Thompson-Ramo-Wooldridge Products, Inc. The new company will concentrate on industrial process control, and will market as its first major product, the RW-300 digital-control computer. Installation of the first RW-300 is already underway for the Texas Co. at Port Arthur, Texas where it will be utilized to control a polymerization unit.

R & D Lab for Smith-Corona

Site for a new $500,000 Smith-Corona Research and Development Lab has been acquired in the Chicago area. The lab will be a modern, one story building, with 20,000 sq ft of floor space and will have a technical and clerical staff of 100 to 125, with

(Continued on page 149)

"Well, there it is . . . all drawn up . . . now where can we engineer a loan to get into production . . ?"

HELI-COIL®

SCREW-LOCK* INSERTS

hold fasteners tight!

Designed for greater speed, safety and economy, Chicago Pneumatic Impact Wrenches exert tremendous tightening and loosening power, resist severe shock loads and rough on-the-job use.

A key feature of their construction is the use of *Heli-Coil* Screw-LOCK Inserts which lock screws within the tapped holes at vital connections. No heavy, protruding lock-nuts are required, no lock-washers. No costly, time consuming lock-wiring. And security? *Heli-Coil* Screw-LOCK Inserts meet Government specs for locking torque and vibration. The wrench is made of aluminum alloy for lightness and ease of handling, but thread stripping in this light metal is eliminated by the stainless steel Screw-LOCK Inserts.

Cutaway showing *Heli-Coil* Screw-LOCK Insert in flange seat of Chicago Pneumatic Impact Wrench.

***HELI-COIL* Screw-LOCK Inserts**

- positively lock screws against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling, seizing
- eliminate need for lock-nuts, lock-wiring, other supplementary locking devices
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Screw-LOCK Inserts are available in a complete range of sizes, including the new miniature 4-40. For more information on how to make your product lighter, tighter, more compact or less costly, write

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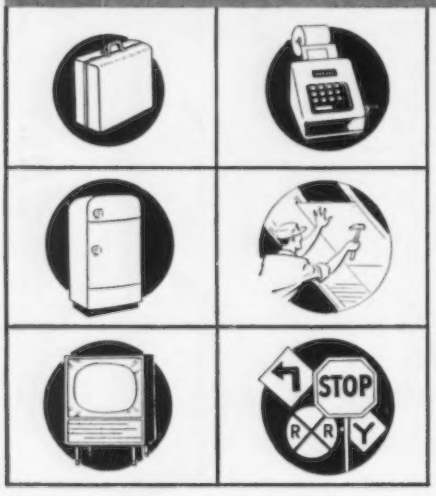
colorful, practical vinyl plastic for lamination to metal



- *Can be permanently laminated to metal . . . flat sheets or continuous coil.*
- *Can be crimped, shaped, bent or drilled without damage to textured finish.*
- *Won't chip, peel or fade.*
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- *Easy to keep clean with soap and water.*
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Industrial Products Division

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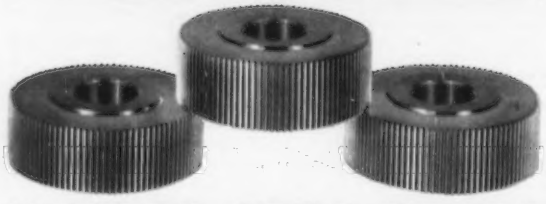

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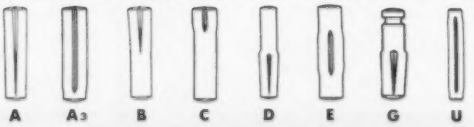


DRIV-LOK PIN COMPANY
723 Chauncey St. • Sycamore, Illinois

provision for additional expansion.

Under the direction of Edward F. Kleinschmidt, vice president for research and development, the research lab will concentrate on printed communications and integrated data processing.

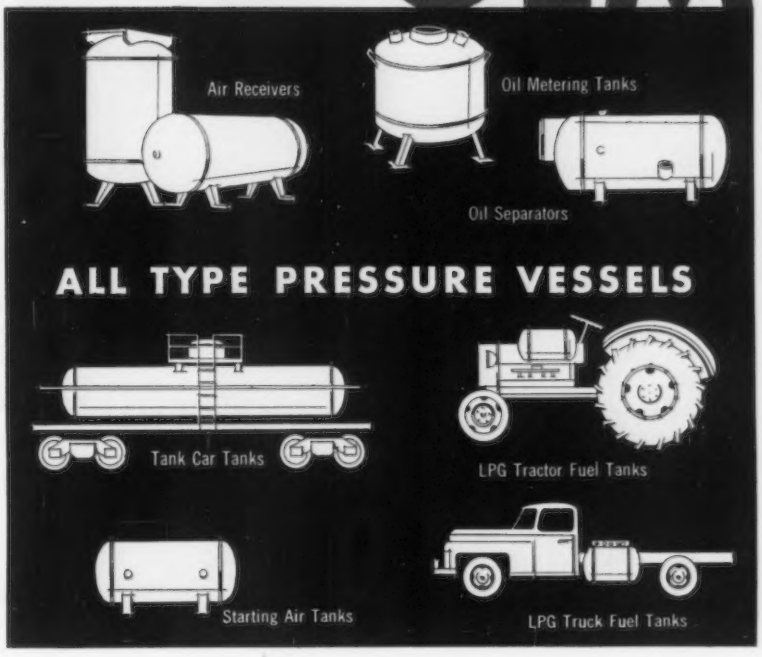
Shell to Build Process-development Lab

Ground has been broken for a new process-development lab at Shell Development Co.'s Research Center at Emeryville, Calif. The half-million-dollar lab will cover some 10,000 sq ft and will enable the company to develop processes for manufacture of new products to the point where they can be scaled up to commercial production.

New Division for Hi-temp Materials

Formation of a company division that will concentrate on high-temperature materials for missiles and rockets has been announced by Rogers Corp., Rogers, Conn., manufacturers of special purpose fibrous and plastics materials. The new activity will correlate more than two years of work on missile materials. Certain of the company's ceramic and ceramic-plastic materials are currently under consideration in several missile projects. Nonclassified data resulting from this operation will be distributed to interested engineers.

FOR OEM



Here are a few of the many items currently being manufactured by Beaird's Special Products Division for *original equipment manufacturers.*

Experienced in code construction, Beaird regularly builds products to conform with ASME, ICC, National Board, Coast Guard, American Bureau of Ships and Underwriters Laboratories specifications. Stress Relieving, X-Ray and a well-equipped inspection department are an integral part of Beaird's production facilities.

If your product uses pressure vessels for air, gas, fuel or chemicals, it will pay you to investigate the savings possible by utilizing Beaird's assembly line production. Write today for a quotation or the services of a qualified Beaird sales engineer. *There is no obligation.*

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Use of Dresser specialized ring-making facilities led to a 19% saving in cost, and a 31% reduction in weight for this generator frame.

If you can visualize your product as a combination of circular shapes, you may be in a position to produce a better product at less cost.

A generator frame, for example, used to be laboriously hogged out of a heavy cast cylinder to proper thickness and contours. Dresser now supplies complete frames made of four accurately formed and welded steel rings. Two rings are steel, of low magnetic permeability; two are mild steel. Machining is all but eliminated.

You can save machining time, speed production and cut scrap losses, too, by using Dresser Weldments. Send for catalog number 56-S. No obligation.

Typical Dresser Weldments

- *Rings and Cylinders*—circular elements may also be combined into composite weldment.
- *Hot-Formed Circular Parts* — extensive banks of presses and furnaces offer you economies in volume production.
- *Shafts or Circular Parts Welded from Dissimilar Metals* — available with a portion of the part resistant to heat, corrosion or abrasion—or provided with greater strength or hard surface in a localized section.

We'll gladly make recommendations at no cost to you. Just send us your sketch or print.

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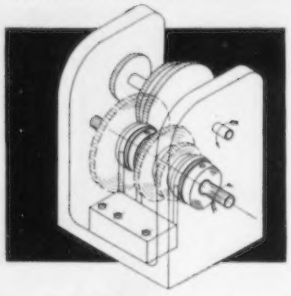
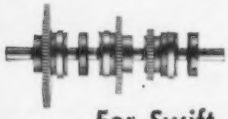


3-speed transmission Composed of gears actuated by miniature Simplatrol Clutches.



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Electric Speed Selection is a key function in automated operation, and Simplatrol Electric Clutches and Brakes are providing extremely swift, silent, economical speed selection in varied installations in instrumentation.

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Simplatrol miniature and small electric clutches and brakes are precision made to close tolerances. There are no sliding parts to wear. The patented diaphragm is the only moving part in the actuation of the clutch and brake. Design is simplicity itself, operation is trouble free.

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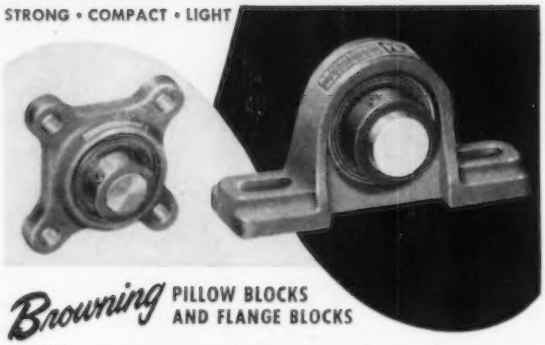
Representation in Key Industrial Areas

NOW... BEARING UNITS OF *Malleable*

STRONG • COMPACT • LIGHT



Browning **PILLOW BLOCKS AND FLANGE BLOCKS**

More compact design and consequent lighter weight are achieved in Browning's new pillow blocks and flange blocks by the use of *malleable* housings that are stronger, virtually indestructible. Contain self-aligning ball bearing units, permanently lubricated and sealed; wide inner ring, eccentric locking ring, safety set screw. Your Browning distributor stocks *two heights*, 28 sizes for ½ to 2 15/16" shaft, all with elongated bolt slots. Ask for new descriptive Catalog BU-101.

Browning Manufacturing Company, Maysville, Kentucky.

Browning **POWER TRANSMISSION EQUIPMENT**

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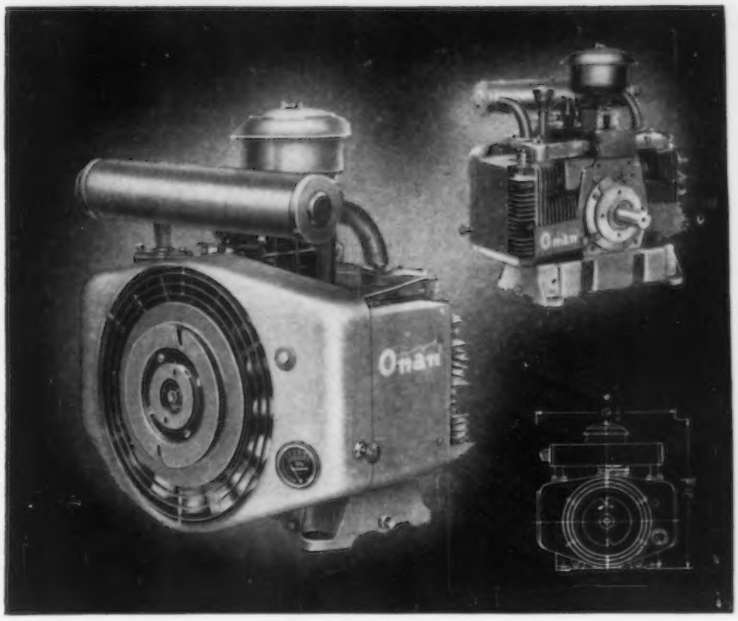
Onan PRODUCTS

AIR COOLED ENGINE NEWS

Onan PRODUCTS



New engine ends vibration problems on power equipment

Alternate-firing, two-cylinder, opposed design Onan CCK runs smoother. Low silhouette and short crankshaft save space.

The Onan 12.9 H.P. CCK engine offers unique advantages for any type of installation. Its smoothness permits mounting in unusual locations since heavy supporting members are not necessary. Because it operates more quietly it can be used where noise must be kept to a minimum.

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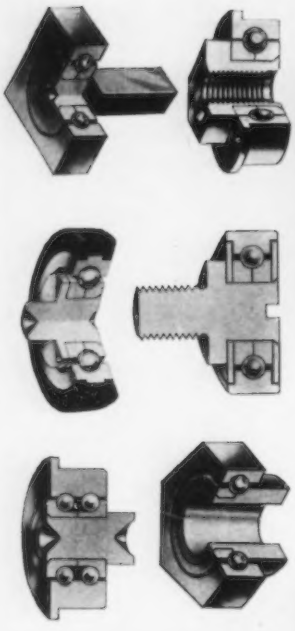

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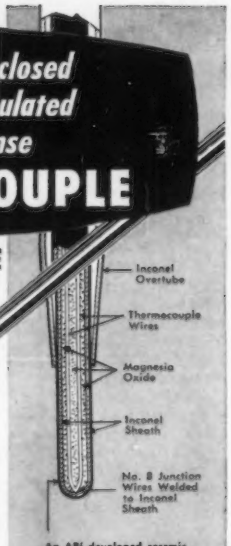

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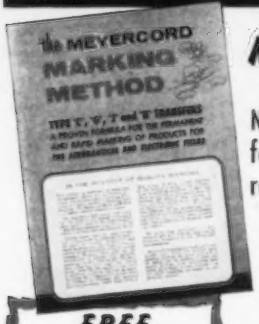

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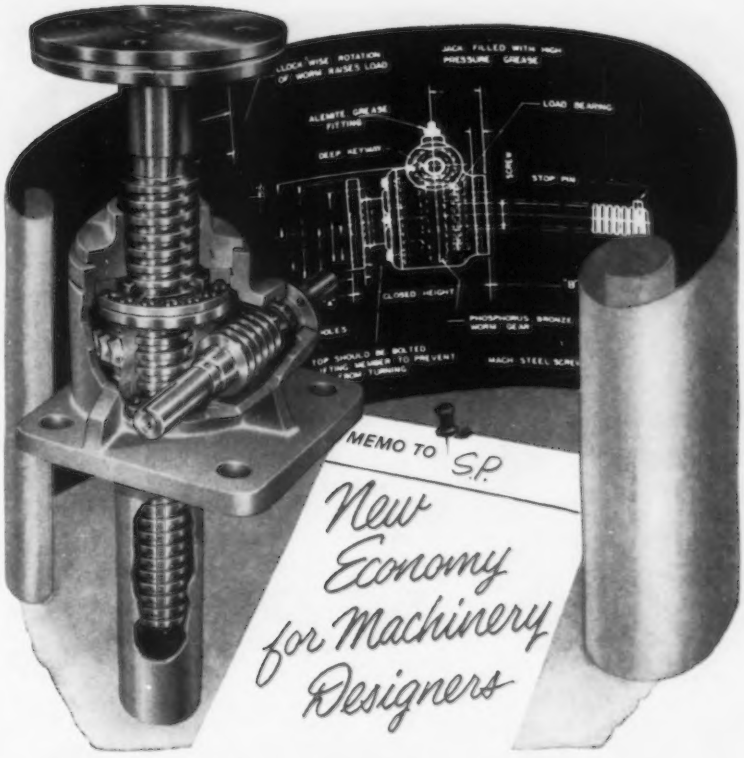

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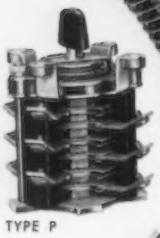
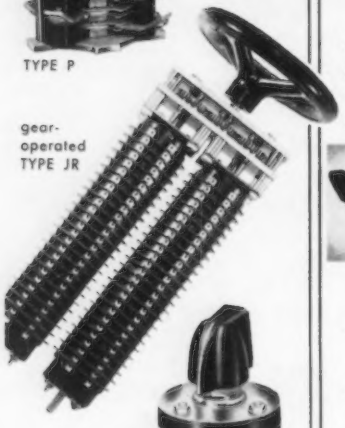


TYPE JR

TYPE P



gear-operated TYPE JR

TYPE A/AF

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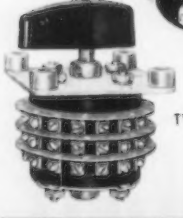

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- *Type P* — Multi-section, up to 4 positions, snap-action, rating 10 amp. 125 volts a-c, 5 amp. 125 volts d-c, 30, 60, 100, 200 amp. 500 volts a-c, or 250 volts d-c. Can be assembled to meet Specification MIL-S-15291.
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- BACKSTOPPING (HOLDBACKS)
- INDEXING (RATCHETING)

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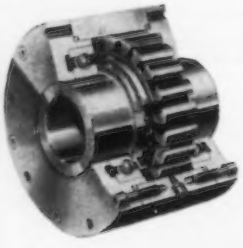

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for continuous high speed overrunning, employs a labyrinth-type oil seal which prevents overheating, excessive wear. Bore diameters. 2½" to 5½"; torque capacity: 1875 to 11,600 ft.-lbs.

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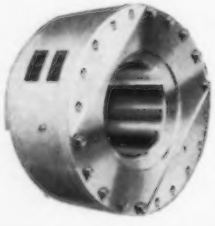
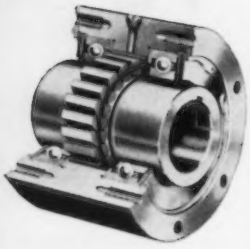
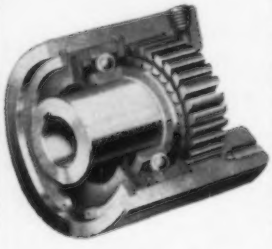




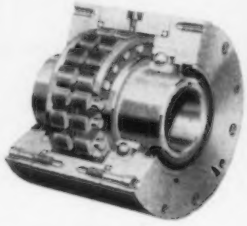
BALL BEARING ALL PURPOSE CLUTCH . . .
designed for maximum accuracy and long life, is ideal where prolonged over-running, or rapid indexing is desired Bore diameters ¼" to 2¼", torque capacity 95 to 1900 ft.-lbs.



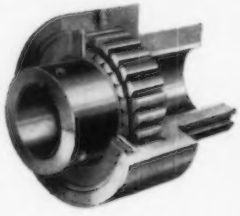
SPECIAL PURPOSE BALL BEARING CLUTCH . . .
designed for end-shaft applications Basically for indexing, but may be used for over-running and backstopping. Requires snap-ring bearing insertion, seal; shaft end must be turned down and threaded for bearing and lock nut Bore diameters ⅝" to 2", torque capacity 60 to 295 ft.-lbs.

MODELS FS-02 AND FS-04 . . .
light-duty, highly accurate, compact clutches, designed to transmit maximum torque where space is at a minimum. They are ideal for business machines, home appliances and small industrial machines. Provision for mounting components. Bore diameters: ¼" to ½"; torque capacity: 50 to 200 in.-lbs.

BALL BEARING SEALED CLUTCH, SERIES "B" AND "C" . . .
incorporate mechanical seals to retain oil on low speed applications, exclude dirt and moisture. For true over-running use series B; for indexing or backstopping, series C. Bore diameters. 2¼" to 5½"; torque capacity. 1875 to 11,600 ft.-lbs.



SLEEVE BEARING CLUTCH . . .
designed for moderate speed applications where loads are not excessive. Generally considered most suitable for use where surrounding mechanism is mounted in sleeve bearings rather than in anti-friction bearings Bore diameters ⅜" to 2" torque capacity 10 to 1310 ft.-lbs.



CLUTCH-COUPLING UNITS . . .
designed for use in coupling two shafts when over-running application is desired. Available in two basic units the smaller size is designed on the basis of bore size for light jobs. The larger is for heavy duty and high torque applications. These clutch couplings use ball bearing clutches FS-400—FS-1000. Bore diameters of coupling. 1" to 7"; torque capacity· 21 to 12,079 ft.-lbs. Bore diameters of clutch: ¼" to 5½".

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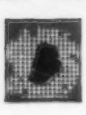
Distributors in principal cities



23607 HOOVER ROAD, WARREN (DETROIT), MICHIGAN. PHONE: SLOCUM 7-8300

IN CANADA: RENOLD CHAINS CANADA LIMITED

IN UNITED KINGDOM: RENOLD CHAINS LIMITED

58-K

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about

- **products advertised**
- **new components and materials**
- **new catalogs and bulletins**

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Now, one of these handy prepaid postcards will bring you more information about any product advertised or mentioned editorially in this issue of *Product Engineering*.

Here's How to Use the Card

For your copy of any new catalog or bulletin, circle key numbers in the space indicated. Bulletins are described on pages 122-129.

To get more data about new Components, Materials and Parts fully described on pages 93-119, just circle the appropriate key number.

To get more information about advertised products, circle the page number of the advertisement in which you are interested. If more than one advertisement is located on a single page, letters preceding number identify each advertisement. Key: T—Top; B—Bottom; R—Right; L—Left; TL—Top left; BL—Bottom left; TR—Top right; BR—Bottom right.

For specialized data . . . prices, sizes available, nearest source of supply, etc. . . . do not circle key number but indicate your needs in the space allotted at the bottom of the card. Use this space, too, if information about a specific product among several mentioned in an advertisement is desired.

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NEW COMPONENTS AND MATERIALS . . .

Description of these new engineering materials appear on pages 93-119. Circle key number for more data

1—Programs up to 85 Circuits
2—Flow Regulator
3—Multipurpose Solenoid Valves
4—Strain-gage Load Cells
5—Reusable Fitting
6—Rubber Compound
7—Door Closer
8—Plastic Gasket Shim Stock
9—Expanded Electric-motor Line
10—Two-way Solenoid Valve
11—Explosionproof Control
12—Oiltight Indicator Lights
13—Miniature Differentials
14—Electric Motors
15—Continuous-duty Air Compressors
16—Rotary Face Seals
17—Terminal Block
18—Shaft-mounted Gear Reducer
19—Digital Strain-gage Indicator
20—Manual Reset Solenoid Valve
21—Heavy-duty Ball Joint
22—Miniature Flexible Couplings
23—Switch Assembly
24—Flush-mounting Toggle Switch
25—Counter-height Enclosures
26—Snap-acting Switch
27—Relays With Dust Covers
28—High-strength Blind Rivet
29—Wide-scale Panel Meters
30—Two-way Solenoid Valve
31—Four-post Drawing Tables
32—Microfilm Planetary Camera
33—Hermetically Sealed Relay

PRODUCTS ADVERTISED

C2	1	2	4	6	8-9	10	11	12-3	14
15	16	25	26-7	28	29	30	31	32	33
34	38	36	37	38	39	40	41	42	43
44	45	46	48	50	79-80	81	84	85	88
90	92	95	97	98	99	100-1	102	103	104
105	106	107	L109	R109	110	111	113	114	115
L116	R116	117	118	119	120	121	122	123	124
125	126	127	128	129	130	131	132	133	134
135	L136	R136	137	TL138	B138	TR139	B139	140	141
142	143	144	145	L146	TR146	BR146	147	T148	BL148
BR148	149	L150	TR150	BR150	151	T152	BL152	BR152	153
L154	156	C3	C4						

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NEW COMPONENTS AND MATERIALS

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33							

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NEW CATALOGS AND BULLETINS

34	35	36	37	38	39	40	41	42	43
44	45	46	47	48	49	50	51	52	53
54	55	56	57						

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listed below are described on pages 122-129. Circle key number for your copy.

34—Solderless Wiring Devices, 8 pp. Electrix Terminals & Connectors

35—Masking Aids, 4 pp. By-Buk Co.

36—Thermosetting Laminated Sheets, 12 pp. New England Laminates Co.

37—Industrial Solenoids, 6 pp. Detroit Coil Co.

38—Steel Tubing Weights, 12 pp. Copper and Brass, Inc.

39—Electromagnetic Relays, 32 pp. Potter & Brumfield, Inc.

40—End Face Seals, 6 pp. Chicago Rawhide Mfg. Co.

41—Filters And Strainers, 20 pp. Cuno Engineering Corp.

42—Heat Exchangers, 8 pp. American-Standard

43—Designing with Aluminum, 56 pp. Kaiser Aluminum & Chemical Sales

44—Repeat Cycle Timers, 2 pp. A. W. Haydon Co.

45—Glass Tubing, Catalog 80-20, Fischer & Porter Co.

46—Superpressure Items, 125 pp. American Instrument Co., Inc.

47—Conveyor Chain and Sprockets, 2 pp. Browning Mfg. Co.

48. Standard Gear Sets, 16 pp. Michigan Tool Co.

49—Sizing and Finishing Internal Diameters, 16 pp. Industrial Tectonics

50—Constant-flow Control Valve, 8 pp. Hobe, Inc.

51—Transistors, 8 pp. Kahle Eng. Co.

52—Bearing Metal, 4 pp. Bearium Metals Corp.

53—Ball Bearings, 4 pp. Shatz Mfg. Co.

54—Packaged Speed-control Drives, 8 pp. Clark Controller Co.

55—Axial Flow Fans, 4 pp. Borg-Warner Corp.

56—Solenoid Valves, 2 pp. A-P Controls

57—Principles of Microradiography, 48 pp. Philips Electronics, Inc.

PRODUCTS ADVERTISED ⇨

NEW PRODUCTS . . . ⇨

NEW BULLETINS . . . ⇨

SPECIFIC DATA . . . ⇨

PRODUCTS ADVERTISED

C2	1	2	4	6	8-9	10	11	12-3	14
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L116	R116	117	118	119	120	121	122	123	124
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BR148	149	L150	TR150	BR150	151	T152	BL152	BR152	153
L154	156	C3	C4						

NEW COMPONENTS AND MATERIALS

1	2	3	4	5	6	7	8	9	10
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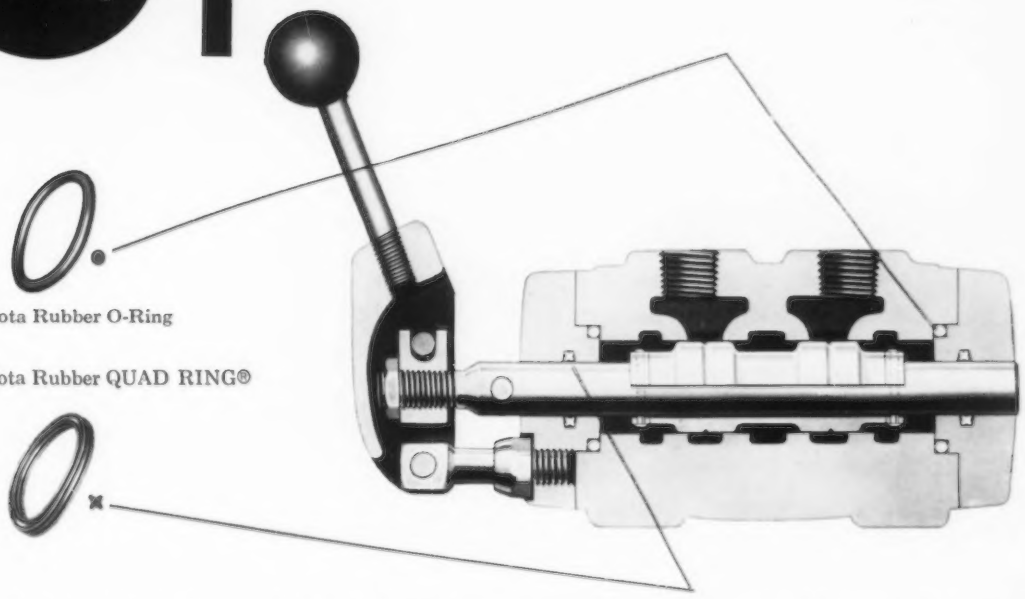
Requests for information made through *Product Engineering* Reader's Service will be forwarded to the manufacturer as quickly as we can process them. If you write directly to the manufacturer, please identify advertisement by issue and page number to facilitate reply.

hydraulics problem:

to improve operation of a pipe-mounted valve

problem solved by:

QUAD RINGS® and O-rings from minnesota rubber



Minnesota Rubber O-Ring

Minnesota Rubber QUAD RING®

To get the utmost in simple, smooth, leakproof operation from their Series 5000 pipe-mounted valve, Rivett, Inc., designed a special floating piston. This exclusive feature prevented sticking and binding by keeping the valve stem independent of the bore. However, it called for a stem seal that would greatly reduce friction.

Rivett found that seal in the Minnesota Rubber QUAD RING. They discovered that the QUAD RING required much less squeeze to make a perfect seal. The hydraulic valve makers found another Minnesota Rubber Product helpful, too.

Minnesota Rubber O-Ring cover seals eliminated and replaced gaskets. This gave three advantages: design simplicity, more efficient operation and longer life.

In fact, this combination of advanced design elements and Minnesota Rubber seals permits multi-million cycle operation at 1500 PSI.

The QUAD RING gives you 4-lip sealing action at less than 1 PSI. The QUAD RING requires only 60-100 micro-inch groove finish and eliminates spiral twist. An exclusive injection molding process makes Minnesota Rubber QUAD RINGS, O-Rings and other rubber parts denser and tougher than standard molded parts.

O-Rings from Minnesota Rubber are available with tolerances as close as ±.002". They cost as little as ordinary O-rings, yet are produced with no flash or other imperfections that require trimming. They are available in a broad range of standard sizes. Special sizes or compounds available on order. For full details on the O-Ring and QUAD RING, write to the department and address listed below. A 16-page facilities brochure is also available upon request.

Need low-cost prototypes? Another technique pioneered by Minnesota Rubber is KOTOKAST This technique means rapid delivery of prototypes for experiment and development at a cost far below those made by standard processes. PROTOTYPES by **KOTOKAST** . . . another step forward by Minnesota Rubber Company.

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for versatility in rubber
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you can improve your product with

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(PRODUCT OF POWDER METALLURGY)

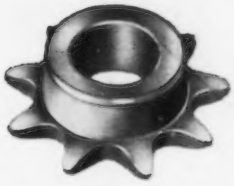
PRECISION FINISHED PARTS

GRAMIX precision finished parts are improving products in virtually every branch of industry. A pump manufacturer, for instance, may specify a gasoline pump rotor made of GRAMIX and gain a number of advantages.

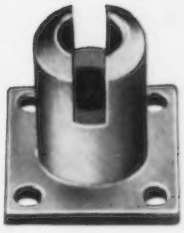
To begin with, the alloys are carefully blended to meet his individual requirements. The GRAMIX parts are then die-pressed to exact shape, sintered under rigid control and finished to tolerances as close as .0005". (This process, of course, costs far less than machining, forging or casting.) The manufacturer can expect the GRAMIX gasoline pump rotor to do a better job because *all* GRAMIX parts are precision engineered and precision controlled from alloying to finishing.

No matter what the application may be, GRAMIX parts fit specifications exactly. Parts may be impregnated with oil . . . to insure a longer life and a quieter operation: if specified, the GRAMIX parts may be coined and work hardened, even prepared for plating.

The rotor is only one of thousands of applications in which GRAMIX precision parts have proved to be ideal. Just a few of them are shown here, so consider the components of your products . . . there may be several that could be improved . . . with GRAMIX! Products of powder metallurgy you can rely on.



Hardened steel drive sprocket for lawnmower

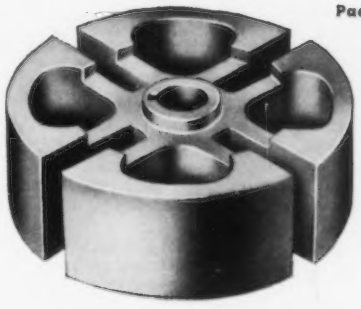


Iron switch control

Rotor for gasoline pump

Packing gland follower used in hydraulic system

Write today for factual Engineering Bulletin No. 21 . . . we'll send your copy.



Bronze rotor in high speed fueling unit

PM MEMBER

X-245-1

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DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

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